BULLETIN

OF

THE INSTITUTE OF PHYSICS

AND

THE PHYSICAL SOCIETY

VOLUME 12 . NUMBER 1 . JANUARY, 1961

CONTENTS

Optical Illusions : Their Influence on Scientific Observation . . . Professor S. Tolansky 1

The requirements of industry for physicists R. E. Bastick 7

Appeal for the Physics Trust Fund 9

Notes and News 10

Reviews of Books 13

Letters to the Editor 16

Forthcoming Institute and Society Meetings . . 18

The Register 23

Manuscripts accepted for publication in the Institute and Society's periodicals . . . 25

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Officers and Members of the Council, 1960-61

President:

SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., M.A., D.Sc., F.Inst.P., F.R.S.

Immediate Past-Presidents of the Institute and of the Society:

SIR GEORGE THOMSON, M.A., LL.D., Sc.D., Hon.F.Inst.P., F.R.S.
J. A. RATCLIFFE, C.B.E., M.A., F.R.S.

Vice-Presidents:

PROF. R. W. DITCHBURN, M.A., B.Sc., Ph.D., F.Inst.P.
A. J. PHILPOT, C.B.E., M.A., B.Sc., F.Inst.P.
W. H. TAYLOR, M.A., D.Sc., F.Inst.P.
J. TOPPING, M.Sc., Ph.D., F.Inst.P.

Honorary Treasurer:

J. TAYLOR, M.B.E., D.Sc., F.R.I.C., F.Inst.P.

Honorary Secretary:

C. G. WYNNE, B.A., Ph.D., F.Inst.P.

Ordinary Members of the Council:

PROF. C. C. BUTLER, B.Sc., Ph.D., A.Inst.P.
E. R. DAVIES, O.B.E., B.Sc., F.Inst.P.
PROF. B. H. FLOWERS, M.A., D.Sc.
J. M. A. LENIHAN, M.Sc., Ph.D., A.M.I.E.E., F.Inst.P.
G. R. NOAKES, M.A., F.Inst.P.
PROF. C. F. POWELL, M.A., Sc.D., F.R.S.
F. A. VICK, O.B.E., Ph.D., A.M.I.E.E., F.Inst.P.
PROF. D. A. WRIGHT, D.Sc., F.R.A.S., F.Inst.P.

Representing Branches:

M. R. HOPKINS, M.Sc., Ph.D., F.Inst.P.
PROF. H. LIPSON, M.A., D.Sc., F.Inst.P., F.R.S.

Executive Officers:

Secretary:

H. R. LANG, B.Sc., Ph.D., A.R.C.S., F.Inst.P.

Deputy Secretary:

N. CLARKE, B.Sc., F.Inst.P.

Editor and Deputy Secretary:

A. C. STICKLAND, M.Sc., Ph.D.

47 BELGRAVE SQUARE, LONDON, S.W.1. TELEPHONE: BELGRAVIA 6111

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute and Society necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute and Society for advice.

UNIVERSITY OF ADELAIDE ELDER CHAIR OF PHYSICS

Applications are invited for the abovementioned appointment. The staff of the Department comprises one Reader, six Senior Lecturers, five Lecturers and five Demonstrators. Present research includes investigation of molecular structure by X-ray diffraction and electron microscopy ; diffusion of electrons in gases ; geophysics ; work on the upper atmosphere. The new Professor will receive every encouragement to pursue his own research interests. Arrangements may be possible for him to participate in space research near Adelaide. The University has a very active Department of Mathematical Physics. The salary now attached to the Chair is £A4,000, with superannuation on the F.S.S.U. basis. Salaries are at present under review by a committee appointed by the Australian Universities Commission. The University has a liberal Study Leave scheme. Candidates are invited to obtain from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar a general statement about the present research and teaching activities of the Department and formal terms of appointment. Those in the United Kingdom may also borrow from the Secretary, A.U.B.C., a coloured film illustrating the University and the City of Adelaide.

Full particulars of schemes under which finance can be made available on favourable terms to help in the purchase of a house may be obtained from the Registrar. The University will gladly supply any further information desired on request to the Registrar. Applications (in duplicate) should reach the Registrar, The University of Adelaide, Adelaide, South Australia, not later than January 31, 1961.

AEON LABORATORIES PHYSICISTS OR PHYSICAL METALLURGISTS

Continuing expansion of the laboratories has created further vacancies for young graduates. Essential qualifications for applicants are experimental deftness, and enthusiasm for crystallography, X-ray and electron optical techniques and deformation studies of metals. The laboratory is well equipped with electron microscopes, X-ray diffraction and fluorescence units and ancilliary apparatus The positions offered are excellent opportunities for people showing initiative to quickly acquire positions of responsibility in research. The laboratory is pleasantly situated and operates the usual pension and other benefit schemes. Apply to: Aeon Laboratories, Beech Hill, Ridgemead Road, Englefield Green, Egham, Surrey.

WESTMINSTER CHILDREN'S HOSPITAL, S.W.1, DEPARTMENT OF CLINICAL MEASUREMENT, newly established for clinical instrumentation problems, measurements in cardiology and respiratory physiology, providing perfusion techniques in some surgical and medical procedures requires SENIOR TECHNICIAN. Applicants from I.M.L.T., Physics or Cardiological grades or with similar scientific experience. Salary in scale £710-£870, plus London Weighting. Apply, naming two referees, to Secretary.

SENIOR LECTURERS or LECTURERS IN PHYSICS, MATHEMATICS, THERMODYNAMICS required by ROYAL MILITARY COLLEGE OF SCIENCE, SHRIVENHAM, Berks., to lecture to London external degree courses (and possibly specialized courses) and assist with laboratory classes. Teaching is at University level. There are extensive well-equipped laboratories; research is encouraged and work would be suitable for publication and submission for higher degree. Qualifications: first or second class honours degree or equivalent, preferably with teaching and/or research experience. PHYSICIST expected to engage in research in nuclear, radiation or solid state physics. MATHEMATICIAN should have interest in applied mathematics. THERMODYNAMICS posts (two) require suitable practical experience; selected candidates expected to undertake or supervise research in thermodynamics or gas dynamics. Salary Ranges: Senior Lecturer £1,250–£1,540, Lecturer £695–£1,144. Credit given for postgraduate experience and National Service in determining starting salary. Superannuation under F.S.S.U. Good prospects of permanency. Accommodation: residential Officers' Mess for single men, houses for married men. Particulars and application forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.556/OA.

McMASTER UNIVERSITY POST-DOCTORAL FELLOWSHIPS IN PHYSICS

Applications are invited for National Research Council and other Post-Doctoral Fellowships tenable in the Department of Physics, McMaster University. Successful applicants may choose to work full-time on their research or to supplement their research with a modest amount of lecturing. Inquiries and applications should be addressed to Professor H. E. Duckworth, Chairman, Department of Physics, McMaster University, Hamilton, Ontario, Canada.

MINISTRY OF AVIATION require ELECTRONIC ENGINEERS for development, planning production or inspection of Guided Missiles and other electronic equipment including communication and radar equipment at London Headquarters branches and other locations. Qualifications : recognized engineering apprenticeship or equivalent training and corporate membership of I.E.E. or exempting qualifications. Experience of modern electronic practice in communication or radar fields desirable and knowledge of guided weapon practice and servo mechanisms advantageous. Salary £830 (age 25) – £1,300 per annum (London, male). Maximum commencing salary £1,125 at age 34 or over (London). Slightly lower rates in provinces with maximum commencing salary £1,095 at age 34 or over. Excellent career prospects and opportunities for established appointments. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.790/OA.

UNIVERSITY OF ALBERTA, EDMONTON AND CALGARY, CANADA

Applications are invited for ASSISTANT PROFESSORSHIPS in PHYSICS at both divisions of the University of Alberta, salary $7,000 up, according to experience. Excellent facilities for research are available, in new buildings. Specialties are Theoretical Physics, Nuclear Physics, Low Temperature, Geophysics, at Edmonton; Cosmic Radiation, Biophysics, at Calgary. For further information write: Professor H. Grayson-Smith, Head, Department of Physics, University of Alberta, Edmonton, Canada.

McMASTER UNIVERSITY GRADUATE SCHOLARSHIPS IN PHYSICS

Applications are invited for Graduate Scholarships in the Department of Physics, McMaster University, from students qualified to register in courses leading to the M.Sc. and Ph.D. degrees. These scholarships may be supplemented by Departmental Assistantships, requiring ten hours per week service during the seven-month academic year, to provide a yearly income (less fees) of $1,875 to $2,175. Graduate Calendars and application forms for graduate study may be obtained from the Secretary of the Faculty of Graduate Studies. Further information concerning the types of research in progress and application forms for scholarships may be obtained from Professor H. E. Duckworth, Chairman, Department of Physics, Hamilton College, McMaster University, Hamilton, Ontario, Canada.

UNIVERSITY OF OXFORD

PRESSED STEEL RESEARCH FELLOWSHIPS

1. The Committee on Pressed Steel Fellowships proposes to make elections in Hilary Term 1961 to fellowships to commence at the beginning of the academic year 1961-2. The number of the elections made will depend on the strength of the field.
2. The fellowships (which are open equally to men and women) are for research in the physical sciences, these being deemed to include organic and inorganic chemistry, physical chemistry, chemical crystallography, physics, colloid science, engineering, metallurgy, or any other subject of study which in the opinion of the committee comes within the scope of the physical sciences.
3. In the selection of fellows the committee will have regard principally to capacity for original work ; and it will normally be a condition of eligibility that fellows shall by the effective date of their appointment have taken the degree of D.Phil., or its equivalent at another university.
4. The annual stipends of fellows will normally be within the range £800 – £1,100. The stipend of a particular fellow will depend on his age and qualifications.
5. Fellowships will normally be tenable for three years.
6. Applications should reach the Registrar, University Registry, Clarendon Building, Oxford, not later than February 11, 1961. Each candidate should submit with his application:
   1. Date of birth;
   2. a statement of his career to date (including degrees obtained) ;
   3. the names of two referees (one of whom should be the head of the department in which he is at present working);
   4. copies of any published papers;
   5. a statement of the department in which he wishes to work, giving an indication of the nature of the work which he would propose, if elected, to carry out.

EDWARDS HIGH VACUUM LIMITED

Manor Royal, Crawley, Sussex

is expanding its resources for research, development and design of pumping equipment, instruments and other apparatus concerned with high vacuum and its applications.

The Company requires

PHYSICISTS or ENGINEERS

to carry out research and development work on vacuum pumps and their accessories : vacuum gauges, vacuum switching devices, leak detection methods, gas analysis, ultra high vacuum techniques, mass spectrometers, electron optics and related topics.

The appointments offer ample scope and opportunity for initiative and originality over a wide field of vacuum physics or engineering. Candidates should have a degree or equivalent qualification in Physics or Engineering with preferably several years' post-graduate experience Recently qualified graduates will, however, be considered.

Commencing salaries for these posts would be in accordance with age and experience. Pensions and Bonus schemes are operated.

Write giving full details to the Personnel Manager.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

AN EXPERIMENTALIST IN APPLIED PHYSICS

is required by

The Radiochemical Centre

for the

Isotope Production Unit at Atomic Energy Research Establishment, Harwell

to supervise a small team engaged in the handling, measurement and canning of large amounts of low specific activity Cobalt-60 and the planning of cobalt irradiation programmes.

Applicants should have G.C.E. at "A" Level, H.N.C. in Applied Physics or equivalent qualifications; a pass degree and background knowledge of reactors and of remote handling techniques would be an advantage.

Salary £1,110 – £1,360 according to age and experience, with prospects of promotion to a salary maximum of £1,900.

Assisted housing and superannuation schemes.

Apply to the

Personnel Officer, The Radiochemical Centre, Amersham, Bucks.,

quoting No. 14/1960/110.

UNIVERSITY OF OXFORD

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWSHIPS

1. The Committee on I.C.I. Fellowships proposes to make elections in Hilary Term 1961 to fellowships to commence at the beginning of the academic year 1961-62. The number of the elections made will depend on the strength of the field.
2. The fellowships (which are open equally to men and women) are for research in physics or chemistry, these subjects being deemed to include physical chemistry, biochemistry, colloid science, chemotherapy, pharmacology, engineering, metallurgy, or any other subject of study which is in the opinion of the committee related to the study of chemistry or physics.
3. It will normally be a condition of eligibility that fellows shall by the effective date of their appointment have taken the degree of D.Phil., or its equivalent at another university.
4. The annual stipends of fellows will normally be within the range £800 – £1,100. The stipend of a particular fellow will depend on his age and qualifications.
5. Fellowships will normally be tenable for three years.
6. Applications should reach the Registrar, University Registry, Clarendon Building, Oxford, not later than February 11, 1961. Each candidate should submit with his application:
   1. Date of birth;
   2. a statement of his career to date (including degrees obtained);
   3. the names of two referees (one of whom should be the head of the department in which he is at present working);
   4. copies of any published papers;
   5. a statement of the department in which he wishes to work, giving an indication of the nature of the work which he would propose, if elected, to carry out.

BULLETIN
OF
THE INSTITUTE OF PHYSICS
AND
THE PHYSICAL SOCIETY

Vol. 12, No. 1 JANUARY, 1961

Optical Illusions: Their Influence on Scientific Observation

Professor S. TOLANSKY
D.Sc., F.Inst.P., F.R.S.
Royal Holloway College, University of London

[Based on a lecture to the Midland Branch of The Institute of Physics and The Physical Society on November 15 1960]

IN MAKING a scientific observation there are often at least three processes involved. First the object must be seen, second it must be recognized and third it is to be assessed or evaluated. Optical illusion can influence all three stages, especially in biological studies. Thus, animal camouflage, essentially operating as an optical illusion, can be so cunningly adaptive and of so perfect a mimicry that an object dissolves in its background and is not even seen. Or again, an object may be seen but camouflage may destroy the outline, and it is not recognized. Such disruptive patterning employs vivid markings and colorations and has frequently evolved with great success. Even so, even if the object is seen and recognized, illusions in a quantitative assessment can arise, as will be shown later.

Here we are concerned primarily with the third stage in the observations, that of assessing some numerical or quantitative estimate of quantity. That optical illusion can have serious consequences even in a field of observation such as physics has hardly been recognized at all. Here I shall describe a large number of geometrical optical illusions, some well known, others new and specially designed. These will demonstrate that there can often be considerable danger if one makes a visual estimate without recourse to exact measurement.

Let me emphasize at the outset that all these illusions, due to a combination of observational defect and faulty psychological interpretation *are defects of no significance as long as a measurement is made*. It is only when an attempt is made to estimate some geometrical property such as distance, area, curvature, angle, and so on, that the illusion causes the observer to make a mistake. The moral of the whole of this contribution is that one must always measure and never rely on guesses and estimates, for they can be devastatingly at fault, as the following article will surely demonstrate.

The basic causes of many of the illusions described here are obscure, but an attempt will be made at an analysis and classification in a general manner. There may be some very acute observers who are indeed not tricked by the illusions, but they are few and far between and certainly exceptional.

Consider first Fig. 1. Here both horizontal and vertical lines are equal, yet almost every observer assesses the vertical line as being the longer. This is in part due to (*a*) the bisection of the horizontal line, and (*b*) in part perhaps physiological, in that the eye always seems to give a false estimate of a vertical compared with a horizontal object. It is said that tree-fellers usually underestimate the length of a felled tree when lying on the ground, compared with a good estimate of the tree height when upright.

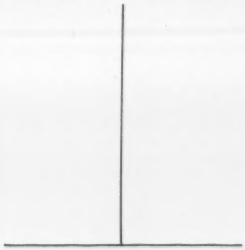


Fig. 1

This simple geometrical illusion leads to one that has been described before and is very striking. In Fig. 2

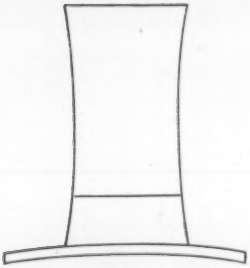


Fig. 2

it is a fact, although considered incredible by most, that the width of the hat equals the height, as a simple measurement will confirm.

Now why do we underestimate the width ? Surely it is because we tend to disregard the weak wing, the brim. That this type of illusion plays a very real part in physical observation is clear from the constant failure of even an expert spectroscopist to estimate the width of a spectrum line. A microphotometer record of a spectrum line is always broader than one thinks the line itself is. It is a failure to take into account the weak wing, like the brim of the hat, which leads to the error, and in like manner an assessment of a slit-width is almost invariably at fault. The slit looks narrower than it is and the long length compared with the width enhances the illusion of narrowness.

CONVERGENCE-DIVERGENCE

I come now to an important class of geometrical illusions based on what I shall call a *convergence-divergence principle*. Fig. 3 has long been quoted in texts. The two lines are of identical size, but the lower looks shorter than the upper. A modification is Fig. 4, in which a line is bisected, but the left half looks shorter than the right. Here, in both 3 and 4, the convergence-divergence principle operates. In 3 the converging arrow heads

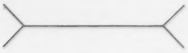


Fig. 3

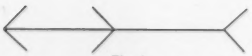
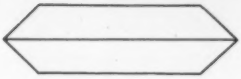


Fig. 4



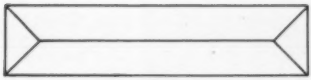


Fig. 5

draw the eye inwards and the diverging arrowheads draw the eye outwards. We are fooled, not by the object itself, but by what lies in the surrounding territory, and we make a false estimate of length.

Two examples of this optical illusion will be now given. In Fig. 5 are two crystals, and it is hard indeed to believe that the central edge (" roof-top ") is the same length in both crystals.

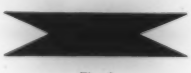


Fig. 6

Fig. 6 is a particularly amusing example I have designed, since it has a very real bearing on the misfortune of the fat lady who hopefully and valiantly ties in her waist as tightly as she can. For it is almost incredible to believe that the width of the central narrow waist is exactly half the width of the top shoulders. It looks almost two-thirds, not half. The reason is clear in terms of convergence-divergence. The divergence mechanism pulls out the waist and the convergence mechanism shortens the shoulder width, with the result that the combination makes the waist appear a good deal wider than it is.

That the divergence mechanism appears to depend rather on the divergence angle is suggested by Fig. 7

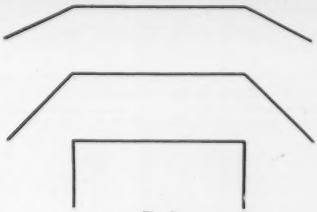


Fig. 7

where the line appears progressively longer as the angle changes. Clearly the eye carries the estimated length along in the direction of the diverging appendanges.

IRRADIATION

Textbooks on optics have frequently illustrated this illusion by means of the diagram, Fig. 8. In both cases the central square is the same size. Owing to perhaps scatter defects in the eye, or irradiation spill-over at image edges on the retina, light from bright regions appears to spread over into dark regions. Thus the dark square on the right appears reduced in size through light encroachment, while vice-versa the light square on the left appears increased. The combined effect makes the inner light square appear larger than the inner dark square.

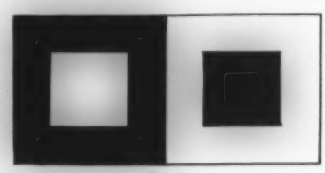


Fig. 8

It must be confessed that this classical illustration is not very striking for the illusion is indeed not very noticeable. Yet I have extended this irradiation principle to help develop a group of really exciting illusions.

Consider first Fig. 9, in which irradiation is the primary factor producing here an excellent illusion. The point here is that the dark circles have been carefully drawn so that the distances between any two circles exactly equals the diameters of the circles. Now this is hard to believe, but it is true. Why are we fooled ? Because here we have a large white area, irradiating into the small black circles, such that they appear a good deal smaller than they are in fact.

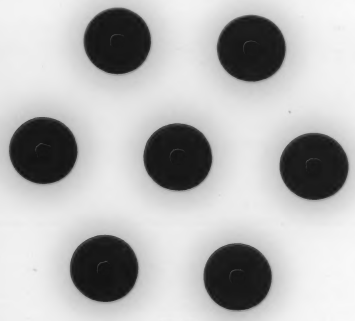


Fig. 9

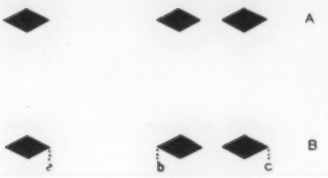


Fig. 10

By combining four separate mechanisms I come now to a striking illusion I have succeeded in designing. These principles are (1) divergence, (2) convergence, (3) irradiation, (4) the falsification of a length between two points introduced by filling in material between the points.

Fig. 10A shows the figure with the illusion and in order not to destroy the effect it is identically repeated below in Fig. 10B with the letters a, b, c added. Now referring again to Fig. 10A and avoiding looking at 10B, it is almost impossible to believe that the distance ab equals the distance bc, yet indeed it does.

Let us analyse the cause of this strange error in assessment. We see that (1) the divergence mechanism increases ab, (2) the convergence mechanism diminishes bc, (3) irradiation makes the lozenge look too small, (4) the distance bc is underestimated because of the material between the two points.

This illusion can now be extended to one which is the most striking I have yet succeeded in designing. This is shown in Fig. 11. Here the feature which is so difficult to accept is the fact that the length of any dark lozenge is equal to the distance between the lozenge and the

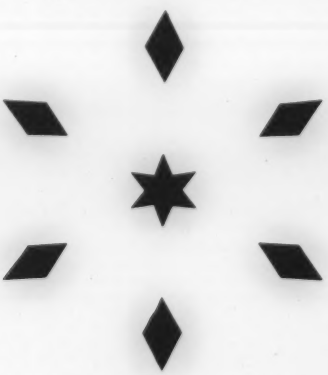


Fig. 11

nearest tip of the central star. I have shown this design to large numbers of observers and without exception they have refused to accept it, yet a simple measurement confirms the validity of the statement of equality.

All the four mechanisms are here operating to mutual advantage. It will be agreed that we are here closely simulating a type of pattern which can appear on biological material and it is well to recognize that attempts to assess sizes of patterns in such cases will go quite awry if no measurement is made. This type of pattern is also not far removed from optical diffraction patterns, Laue spot patterns and electron diffraction patterns, and it constitutes a warning about visual estimates in such instances. As always, of course, no mistake is made when *measuring*, the mistake only arises when assessing *without* measuring.

AN INDENTATION TEST ILLUSION

The convergence-divergence principle accounts for a curious illusion which arose in some experiments I made involving hardness testing. One standard method of testing hardness of a metal is to make an indent, under standard load, with a diamond pyramid. In a homogeneous material this leads to a square-shaped indentation, such as that to the left, Fig. 12. However, in these particular experiments an indent made on single crystals of tin had the shape shown by the figure to the right, Fig 12. The directional properties of the crystal produced flow effects leading to the biconvex-biconcave shape shown.

Now the illusion here is, that it is almost impossible to believe that the two diagonals in the concave-convex figure cross each other *at right angles* and are also equal in length to the diagonals of the square on the left. To prove that they must be, a linear grid has been drawn on top of the patterns. It will be seen that the square to the left has a side of three units, whilst the corner points of the concave-convex figure to the right also lie identically on a square of side three units. In other words the diagonals of both figures must be identically the same, bisecting at right angles.

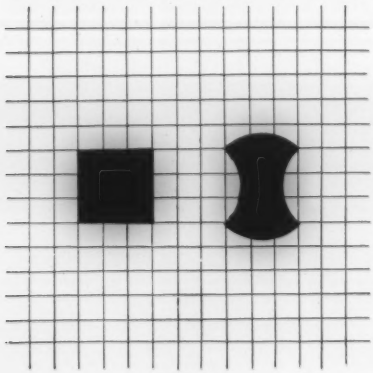


Fig. 12

I admit freely to having been fooled by this indentation pattern and only recognized the illusion after making measurements, for of course the revealing grid has only been added here to convince the incredulous and was not on the original. It is largely convergence-divergence which produces this illusion and we see once again that it is the character of the surrounding territory which always influences our assessment of a situation.

AN OSCILLATION ILLUSION

Many will be familiar with the mental phenomenon of oscillation and an example often quoted is that shown in Fig. 13. Here some people see a black vase at first

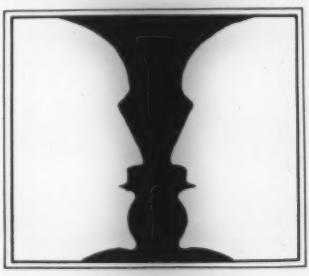


Fig. 13

viewing, others two white faces opposite to each other. To quite a number of observers, there can be oscillation from one pattern to the other. I have come across quite striking oscillation illusions in a number of micro-photographs of surfaces, and this effect is shown in Figs. 14 and 15. Fig. 14 is a rather beautiful picture of a block micro-etch pattern produced on a diamond face. Magnification is × 1000. The picture is definitely that of a group of blocks standing out proud, indeed it was jokingly called in the laboratory an aerial view of " Diamond Manhattan " skyline.

This micro-picture was secured with oblique illumination, which gives an impression of shadows being cast.

Now Fig. 15 is precisely the same picture as Fig. 14, but it has merely been turned upside down. The result is most surprising, for instead of seeing blocks standing out we now see recesses, hollows instead of hills.

Here we have an error in interpretation which is due to an illusion, for which picture is right ? Are they hills or hollows ? It is almost certain that this illusion arises from our instinctive interpretation of shadows cast by a sun always above us and never below us.

The oscillation comes in with many if the page be turned through 45° (or less) when sometimes the pattern appears as elevated blocks, at other times as recessed depressions.

CROSS-WIRE ILLUSION

I choose now for illustration some considerations about cross-wires and it will be seen that we run into a most curious illusion which scientifically is as disturbing as it is unexpected. We begin with an illusion which has been described before and analyse its character.

In Fig. 16 a broad band is crossed by parallel lines A, B, X. Now almost without exception every observer believes that B and X are in straight line, i.e. that X is the continuation of B. This is not so, for application of a ruler will surprise the reader into finding that A and X are colinear, not B and X.

That the illusion does not depend on transparency or opacity of the broad object is shown by Fig. 17, and that it is not affected by a multiplicity of lines is also shown by Fig. 17, for in each case it is the second line from the top which is the correct continuity whilst it invariably appears to be the top line. Most disturbing of all is the modification shown in Fig. 18. Here one is quite convinced that the left parallel pair are in direct continuation of the right parallel pair. Yet in fact only the top left and bottom right lines are colinear. The illusion is complete and an absolute error is made.

Note that this illusion is at its maximum when the eye is perpendicular to the paper. If one holds the paper horizontally and glances at grazing incidence along the direction of the narrow parallel lines the illusion is destroyed, and this is true for all examples from Fig. 16 onwards. Indeed such viewing is a more severe test of colinearity than the application of a ruler.

That the illusion under discussion depends primarily on the angle of intersection is shown by the sequence in Fig. 19 where, proceeding from left to right, it becomes quite apparent that the illusion is progressively destroyed as the inclination of the cross lines is reduced.

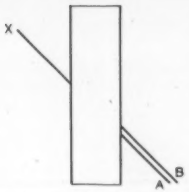


Fig. 16

Fig. 17

Fig. 18

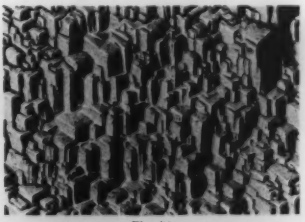


Fig. 14

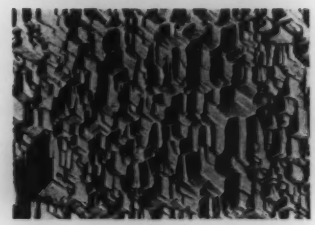


Fig. 15

Fig. 20 shows that the illusion is unequivocally decided by the width of the object being crossed. For with the wide object in Fig. 20A the illusion is strong, but with the narrow object in Fig. 20B there is no illusion at all, and no error is made.

These are general conclusions which have a bearing on cross-wire design for instruments. Fig. 19 indicates that it is advantageous in cross wire design to have wires like Fig. 21A rather than Fig. 21B.

Fig. 20 shows that this cross-wire defect does not arise when a thin narrow object or slit is being viewed, but is only significant when a broad object is being set on. This may well explain why the illusion has not been recognized by instrument designers. In any case only under certain conditions of illumination of objective and cross wires do we fail to see the wire crossing the object, and this is clearly a necessary condition, for it is obvious that no illusion exists if the lines are seen running across the object itself. Yet often illumination conditions are such that the observer relies, not on the centre of the cross wire, but on the symmetry of setting and it is here that danger might well arise.

Fig. 19

HATCHINGS

There are numerous other geometrical patterns which interfere with observation and only one example from many will be quoted. Most are familiar with the distorting effects on parallel lines and corners, etc., produced by cross-hatchings. Effects like this are surprisingly common in interferometry, where a surface pattern is crossed by rows of parallel straight or curved interference fringes, and a confused idea of the surface pattern results. For example in Fig. 22 there is drawn *a perfect circle*, but it looks quite distorted because of the hatchings. Such a fringe pattern is quite common in interferometry and it is easy to be tricked.

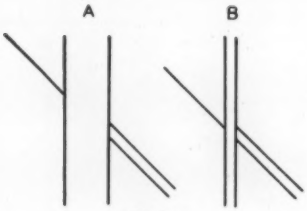


Fig. 20

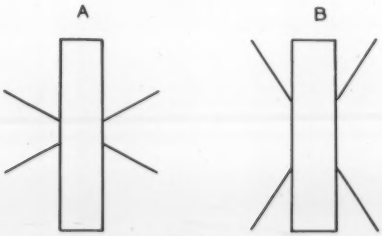


Fig. 21

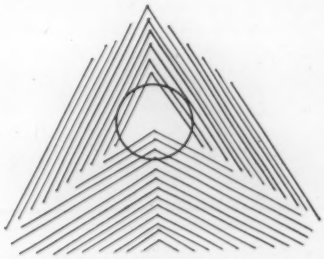


Fig. 22

CONCLUSION

We see that consideration of these optical illusions is quite a serious matter for the scientific observer. They are not mere parlour tricks of entertainment. They are defects in observation and assessment which do really interfere with interpretation if one neglects to make accurate measurement. These defects are of little consequence if one is aware of their existence, but if not, appreciable errors can be made.

One can only conclude with the admonition : one should measure, measure, measure !

The requirements of industry for physicists (2)

R. E. BASTICK
B.Sc., Ph.D., A.Inst.P.
Chance Brothers Limited, Smethwick.

[Based on a talk given to the Conference of the Education Group and the Midland Branch on April 22, 1960.]

Mr. Mountjoy has approached the problem of the training of the industrial physicist from the viewpoint of a large organization in the chemical and metallurgical industries. For my purpose, I propose to discuss the requirements of the medium and smaller sized firms. The division is a convenient one for, two reasons:

(1) The large organizations have well established research departments which have grown rapidly over the past few years and although this growth will obviously continue we may expect the curve to become asymptotic. It will be limited by economic considerations and the rate of growth will tend to diminish. On the other hand there are many small firms that at one end of the scale maintain medium sized laboratories which if they are to make progress should expand at a relatively greater rate, while at the other end of the scale the necessity for scientists and in particular physicists has not yet been realized.

(2) The larger organization is usually a producer of basic raw materials, e.g. metals, chemicals, plastics, paper, glass, while the smaller firm is concerned with fabrication from the raw material; therefore the larger organization is more concerned with developments of a fundamental nature and the smaller firm with the application of the fundamental discoveries.

It would appear therefore that there is likely to be an increasing demand for the applied physicist in the smaller firm and it is worth while considering the type of training for such a man. First, I would like to describe briefly the kind of training we have adopted in our own organization which until a few years ago was an independent Company with about 2,000 employees. Its laboratory was responsible for maintaining and improving the quality of its products and the efficiency of its processes, and in the development of new products and processes. Although now part of a larger organization with a laboratory concerned with more fundamental research, its responsibilities remain substantially the same. Indeed they have increased to some extent since its specialized knowledge is of value to the Parent Organization. This pattern of integration of a small firm with a larger one is familiar and I believe we shall see it repeated many times in the next few years. We have then, a laboratory responsible for control of industrial processes with research and development arising more or less directly from problems associated with the processes and with its own particular products. Although it has a large research organization behind it, its requirements are essentially those of a smaller firm.

For many years we have relied on a nucleus of graduates from the Universities with junior assistants who have attended a Technical College under a part-time day release scheme, the usual goal being the external degree of London University. While the system was reasonably successful, it was of limited application because of the small number of juniors who were regarded as capable of attaining degree standard. In recent years the possibility of alternative qualifications, although at different levels of academic attainment, have presented themselves, namely, the National and Higher National Certificates in Applied Physics leading to Grad.Inst.P. and more recently, the Diploma in Technology (Applied Physics), and the necessity for a qualification for all juniors is now recognized.

We come then to the problem of deciding first of all on the qualities of the would-be physicist and then on the respective merits of the types of training available for him. In considering these it must be pointed out that those school leavers applying for posts in industrial laboratories are usually in the second string, the best of them, at least from the point of view of examination results, having already found places in the universities. If, as we are told, only about 5 per cent of the applicants fail to find places in a university, industry can hardly expect many recruits of high quality. It is only on the rare occasion and for some personal circumstance that a boy of university standard presents himself for interview.

First of all we have to consider the school leaver at Ordinary G.C.E. level. Here we look for the basic subjects, mathematics, physics and chemistry, but how frequently do we find that the student has passes say in general science, biology, and perhaps has failed in mathematics? This is perhaps an extreme case, but satisfactory passes in the three basic sciences are almost a rarity. I suspect that at the beginning of the Ordinary level course, the school has an eye on the possible examination successes and it is convenient to leave out the basic sciences for the less able students. Yet a year or two later the student is presenting himself for a post where he will be expected to have passed examinations in these subjects. It seems incredible that such students should be advised to apply for such posts.

Assuming that the student has a reasonably satisfactory G.C.E. level standard it is now necessary to decide on the course to be followed. In many cases there is no alternative but to advise the National Certificate course. The standard reached at Higher

National level produces good technicians but is unlikely to satisfy the demand for well qualified physicists. I suggest therefore that the schools should pay more attention to the demand and give more consideration to the prospective future of a student than they appear to do at the present time.

At the Ordinary National level it is hoped that certain students will achieve a sufficient standard for consideration for the Dip.Tech. course and we can now include the student who has come from school with Advanced level G.C.E. So far as the National Certificate student is concerned the employer has probably been able to reach a conclusion based on three years' performance at work and at college, but for the student coming straight from school the decision is a difficult one because only the school report and the results of the G.C.E. are available as evidence. To give an employer a sounder basis for his decision it seems necessary at the moment to advise one year at S3 level which may mean that the student is repeating work already done. This may not be a bad thing but with the prospect of a four year Dip.Tech. course he is reluctant to add a further year by taking S3. A sound choice at O.N.C. or G.C.E. Advanced level is however, a matter of some importance because of the risk run both by the firm and the individual. In the event of failure at any time during the Dip.Tech. course, the student is left "high and dry" and at the present time there is no satisfactory alternative unless he now starts the H.N.C. course at A.1. I am sure that selection for the Dip,Tech. course is a matter of some difficulty which is bound to have its effect on the support given, particularly by the smaller firms.

I now want to discuss the requirements of industry so far as a graduate is concerned and I feel it is desirable to compare the relative merits of the university graduate and the Dip.Tech. student. The smaller organization is unlikely to employ many people entirely on pure research and generally the physicist will be engaged on the solution of problems arising directly from production, together with some applied research. The work inevitably involves close contact with the production side and calls for qualities other than purely technical ones. Broadly speaking, he must be able to get on with all kinds of people and his success will be dependent upon his ability to get his ideas into practice.

It is surprising how many graduates fail to demonstrate these qualities, at least at interview, and it seems obvious that they have not taken advantage of a university education in its widest sense. At a university the extent to which the student develops in this sense depends very largely on the individual, but on the other hand the Dip.Tech. course, by incorporating liberal studies in its syllabus, attempts to deal with this aspect. While the form of the liberal study is debatable, I think we are more or less agreed on the necessity for it. In this connection I would suggest the introduction of such relevant topics at Patent Law, Safety in Factories, the Structure of Government Research Organizations, the Research Associations and sponsored Research Institutions. These are things that the physicist in industry will meet sooner or later and it is well that he should know something about them.

It seems to me that all other factors being equal, the choice of a candidate for a university or for a college of advanced technology should depend to some extent on an assessment of his potential for self development. This raises the question of some collaboration between universities and colleges at the selection stage and perhaps puts a further responsibility on some form of clearing house. There are admittedly, some difficulties. I can well imagine that the student who is adequately equipped academically for a university course will hardly take kindly to a suggestion that he would benefit more from a Dip.Tech. course. For some time to come, at least until the Dip.Tech. has established itself as equivalent to a university degree, the colleges of technology will suffer from odious comparison. I think that perhaps if they were called "Technical Universities" the obstacle would be overcome.

So far as the present postgraduate training is concerned my view is that the university training is too specialized for the industrial physicist in the smaller concern. The ability to get to the root of a problem and to find a solution to the problem is certainly necessary and I suggest that the desirable attributes are initiative, versatility and a wide basic knowledge with a flare for improvisation. I would also add the ability to solve a problem quickly. This becomes more important as industry becomes more highly mechanized. We are familiar with large scale university research carried out by teams of workers and it has been said that the age of "string and sealing wax" research is past. In my opinion the more individual approach to research is a better preparation for industry. The matter is discussed fully in the recent report, *The Postgraduate Training of Physicists in British Universities*, and its comments are relevant to our considerations. But not all students will have the opportunity for postgraduate training and I would like to know more of the attitude of the teaching establishments to the training of the undergraduate student in solving problems from first principles. Do they still rely on the stereotyped experiment to be carried out according to the book ? I am quite sure industry can provide the colleges with many examples which have to be tackled from first principles—examples where the critical faculties of the student can be exercised.

Finally, under the heading of postgraduate training, I would include the practising physicist in industry. Starting as a pure or applied physicist, he finds himself specializing in a particular field of technology and so his sphere of interest widens rapidly. One of his main problems is to keep abreast of progress in the wider fields. This is probably not so difficult in so far as his particular branch of technology is concerned, because the advances in it generally depend on the applications of principles already well known to the physicist. However if he is worth his salt, he will want to learn something of the advances in fundamental physics and here he has a much more difficult problem. The Branches of the Institute, by providing lectures on a wide variety of topics, go some way towards fulfilling the need, but I am sure that many of us would like to see more refresher courses sponsored by the universities and dealing with basic physics just as the technical colleges are active in arranging courses in applied physics.

There is, of course the difficulty of arranging courses for people who are busy anyway, but I would suggest that if organized on the basis of weekly lectures outside working hours they would receive considerable support.

This then is the picture as I see it so far as the smaller organization is concerned. Many of the problems are common to industry as a whole but let us remember that our first problem is that of making the best use of student material at whatever academic level. The current expansion of the physics departments of the universities and colleges of technology is all very well but the material has to be found to fill places and I believe that a start must be made in the schools if the expected needs of industry are to be satisfied over the next few years.

Appeal for the Physics Trust Fund

The following donations or subscriptions were received between December 1 and 23:

(*a*) From members

Dr. W. D. Allen
Mr. R. G. Angus
Sir Edward Appleton
Dr. T. E. Banks
Dr. B. Barber
Dr. H. Barrell
Mr. W. H. Barton
Dr. R. E. Bastick
Dr. K. G. Budden
Dr. W. Bullerwell
Mr. G. J. Camfield
Dr. J. Christian
Mr. J. A. Clayton
Mr. W. E. Copsey
Professor J. D. Craggs
Mr. B. L. Davies
Professor C. Domb
Professor B. H. Flowers
Dr. J. W. Fox
Mr. N. T. Gallagher
Mr. J. Glazer
Mr. J. C. Guthrie
Mr. J. K. Jones
Dr. H. G. Kuhn
Mr. J. W. Lewis
Mr. T. Martin
Mr. S. A. F. Murrell
Mr. G. R. Noakes
Mr. A. Pelican
Mr. A. J. Philpot
Mr. A. Porter
Mr. K. J. Proud
Mr. H. P. Rooksby
Dr. R. A. Scott
Dr. G. W. Scott Blair
Mr. V. H. Sharp
Mr. J. Shaw
Dr. R. W. Sillars
Mr. R. J. Slaughter
Dr. T. V. I. Starkey
Dr. F. A. Vick
Mr. P. Weston
Dr. B. Yates

(*b*) From firms

W. H. Allen, Sons & Co. Ltd.
Aluminium Laboratories Ltd.
R. M. Catterson-Smith Ltd.
Central Electricity Generating Board
Colvilles Ltd.
Thos. Firth & John Brown Ltd.
General Precision Systems Ltd.
Glaxo Laboratories Ltd.
Guest Keen & Nettlefolds Ltd.
Imperial Aluminium Co. Ltd.
J. Langham Thompson Ltd.
Marshall of Cambridge Electronics Ltd.
Methuen & Co. Ltd.
Pye Ltd.
Reckitt & Colman Holdings Ltd.

The total received or promised by December 23 (including those previously announced) was :

	£
Gross value of industrial firms' covenants over seven years (including tax recoverable)	70,795
Single donations from firms	6,128
Total from Industry ...	76,923
Gross value of members' covenants over seven years (including tax recoverable)	3,956
Single donations from members	400
Total from members ...	4,356
GRAND TOTAL at December 23, 1960	£81,279

Notes and News

London and Home Counties Branch

"At Home"

The London and Home Counties Branch held an "At Home" at 47 Belgrave Square on October 28. About 150 members and their friends attended and the program was similar to that of the four previous "At Homes" that have been held at roughly two year intervals. Members and guests were received by the Branch chairman, Professor A. M. Taylor and Mrs. Taylor. Several rooms were devoted to exhibits and films were shown in the Council room. Supper was served in the Council room.

Mr. S. N. Ray (left) with Professor and Mrs. Taylor.

Mr. E. N. Clarke, Dr. J. S. Forrest and Dr. D. A. Fallon.

A group looking at one of the exhibits. On the right, bending down, is Mr. R. E. Burnett.

Payment of annual fees

Members, Students and Subscribers are again asked to co-operate in reducing the cost and labour of collecting fees by using the form printed on page iv. This form is *not* intended for those members who pay fees by bankers' order.

Rutherford Jubilee International Conference

To commemorate the discoveries of Rutherford at Manchester and in particular the fiftieth anniversary of the discovery of the Rutherford scattering law, an international conference on nuclear physics is to be held at the University of Manchester from September 4 to September 8, 1961. This conference, which is to deal primarily with low and medium energy phenomena, is sponsored by the International Union of Pure and Applied Physics, The Royal Society, The Institute of Physics and The Physical Society, and the University of Manchester.

Those wishing to attend this conference are requested to ask for further information from the Conference Secretary, Dr. L. J. B. Goldfarb, Rutherford Jubilee International Conference, Physics Department, The University of Manchester, Manchester 13.

Binding of the Bulletin

Members who wish to have their 1960 volume of the *Bulletin* bound are asked to send the twelve issues direct to the printers, F. J. Milner & Sons Ltd., Commerce Road, Brentford, Middlesex, as soon as possible, enclosing a sheet giving the name and address of the sender and a remittance made payable to the firm. The cost is 24s. 6d a volume, including return postage. The binding is in red cloth with gold lettering on the front and spine.

A title page and contents list will be bound with each volume.

Contributions to the Bulletin

Although there is a large amount of material in hand for publication in the *Bulletin* the Editor is always glad to consider contributions from members in the form of either short articles or correspondence. Articles of less than 2,000 words are always particularly welcome. They may be on any topic likely to be of interest to members and not so predominantly technical in nature that they would be more suitable for publication in one of the Institute's scientific journals. All articles submitted are subject to refereeing. Manuscripts should be addressed to Mr. N. Clarke at Belgrave Square.

Symposium on User Experience of Large-Scale Industrial Vacuum Plant

Following a recommendation by the Joint British Committee for Vacuum Science and Technology on which the Institute and Society is represented, the Institution of Mechanical Engineers has arranged a Symposium of papers on user experience of large-scale industrial vacuum plant, to be held at the Institution on March 1 and 2, 1961.

The main objective of the Symposium is to bring together designers and users of vacuum plant to discuss their problems and techniques. The Joint British Committee feel that designers and manufacturers will benefit from the opportunity to learn about users' experience with such plant, and that users will welcome an opportunity to place their experience on record.

The arrangements for the Symposium are being made by a Committee consisting of representatives drawn from constituent bodies of the Joint British Committee.

It is planned to discuss some twelve papers, which will be preceded by a general review paper.

The provisional programme is as follows :—

Wednesday, March 1, 1961, 4.0 p.m. to 5.0 p.m.
Review paper, followed by a group of papers on vacuum processing and treatment of metals.

Thursday, March 2, 1961, 9.30 a.m. to 1.0 p.m.
Further papers on metallurgical subjects, together with a contribution on steam ejection vacuum plant and a paper on capacitor drying.

Thursday, March 2, 1961, 2.0 p.m. to 5.0 p.m.
A group of papers covering medical and food processing aspects.

Refreshments will be provided for delegates on each day.

Registration will be required for which application should be made to the Secretary of The Institution of Mechanical Engineers.

More detailed information on the arrangements, together with a list of papers will be published in due course.

Nato Summer School

Under the sponsorship of N.A.T.O. a Summer School will be organized at Ghent University (Belgium) from July 24 to August 5, 1961. The program concerns electrical, optical and mechanical properties of lattice defects. A detailed program and further information can be obtained from Professor W. Dekeyser, Laboratorium voor Kristallografie en Studie van Vaste Stoffen, Rozier, 6, Ghent, Belgium.

Nuclear Magnetic Resonance Spectroscopy

An introductory symposium on the "Applications of Nuclear Magnetic Resonance Spectroscopy" will be held at the Bradford Institute of Technology on January 27 and 28, 1961. The speakers will include Drs. D. F. Evans, J. Feeney, D. W. Jones, N. Sheppard, J. A. S. Smith and I. M. Ward. There is a registration fee of £2 5s. 0d. Further information may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

Annual Dinner and Presidential Address

Members are reminded that the Annual Dinner of the Institute and Society will be held at the Park Lane Hotel, London, on May 2. The Presidential Address will be given by Sir John Cockcroft on the afternoon of that day. Application forms for tickets will be issued in February.

The British Society of Rheology

A meeting on theoretical rheology will be held at Reading on April 20 and 21, 1961. It is intended that speakers should emphasize the physical aspects of their work, rather than the mathematics only, since it is expected that a wide range of interests will be represented amongst those attending the meeting. Further information may be obtained from Dr. M. F. Culpin, F.Inst.P., 8 The Broadway, Pontypool, Mon.

Paul Instrument Fund

The Paul Instrument Fund Committee, composed of representatives of The Royal Society, The Institute of Physics and The Physical Society and The Institution of Electrical Engineers, was set up in 1945 " to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science ".

Awards of grants have recently been made as follows :

£1400 per annum for two years, in supplement of a previous grant, to Professor G. F. J. Garlick, F.Inst.P., department of physics, University of Hull, for the continuation of work on solid state light image amplifiers.

£2,000, in supplement of a previous grant, to Professor D. Gabor, F.Inst.P., F.R.S., professor of applied electron physics at Imperial College in the University of London, and Dr. D. Jones, for additional equipment for use in connexion with the development of an electron interference microscope.

The Committee invites applications for grants. Grants can be made for or towards the provision of equipment, building facilities or financial or other aid in such manner as the committee may determine in each case. Grants from the fund shall not be used to relieve expenditure in any establishment controlled by the Government or to relieve any university or other educational establishment of their normal financial obligations, but grants to research workers in them can be and have been made for investigations which would not normally be regarded as an obligation of such establishments.

Addresses for communications

All the editorial work of the Institute and Society, with the exception of the editing of the *Bulletin*, is now concentrated at 1 Lowther Gardens, Prince Consort Road, London, S.W.7. Manuscripts and all correspondence relating to the editorial content of the *Journal of Scientific Instruments*, the *British Journal of Applied Physics* and the *Proceedings of The Physical Society* should be sent to that address. All other correspondence for the Institute and Society, including orders for the above publications, should be sent to 47 Belgrave Square, London, S.W.1.

Textile Physics Conference

The Physics Group of the Textile Institute is planning a Conference in Coventry on April 13 and 14 1961. The theme will be " Physics in the Production and Processing of Yarns ". Anyone wishing to have any further information should get into touch with Dr. H. O. Puls, F.Inst.P., Research Department, British Nylon Spinners Ltd., Pontypool, Monmouthshire.

Reviews of Books

ELEMENTS OF THE THEORY OF MARKOV PROCESSES AND THEIR APPLICATIONS

By A. T. Bharucha-Reid

London : McGraw-Hill Publishing Co. Ltd. Pp. xi + 468. Price 89s.

Nearly every branch of physics has to deal with some sort of random process, in which movement from the present to the future is not deterministic, but is given by a series of transition probabilities. If these probabilities do not depend at all upon the past (i.e. how the system came to be in its present state) but solely upon the present (i.e. the state in which it actually is), we speak of a Markov process, in honour of the Russian mathematician A. A. Markov, who died in 1922.

There are essentially three kinds of such process. The first are discrete in both space and time (e.g. a random walk along a lattice) ; the second are discrete in space and continuous in time (e.g. the random division of a cell as occurs in most forms of the birth-and-death problem) ; the third are continuous in both space and time (e.g. the diffusion of a molecule in a liquid in Brownian motion). The present book starts with a clear discussion of these three main processes, and then proceeds to illustrate them in many different fields. Even to list these is to reveal the wide generality of the original concepts—population growth and epidemics, electron-photon and nucleon cascades in cosmic radiation, nuclear tracks in photographic emulsions, radiative transfer and the light of the Milky Way, chemical kinetics, queueing and operational research. It is an impressive list, matched by the impressiveness of the account. This book is suitable for final year honours students or first-year postgraduates at most British universities. It is mathematical in character, and useful appendices derive many results in the theory of generating functions, and in Laplace and Mellin Transforms.

One particularly pleasing aspect is the close contact maintained by the author with Polish mathematicians. As a result this book contains far more references to Russian, Polish and Hungarian work than most books of its kind. It is weakest along the chemical side, where no reference is made to the work of N. B. Slater on reaction rates and first-passage times. But in general it is magnificently up-to-date, and—in view of the inevitable difficulty of type-setting with so many differential equations—extremely readable. It is a pleasure to recommend it.

C. A. Coulson.

SERVOMECHANISMS AND REGULATING SYSTEM DESIGN—Volume I

By Harold Chestnut and Robert W. Mayer

London : Chapman & Hall Ltd. New York : John Wiley & Sons Inc. Pp. xvii + 680. Price 94s.

When the first edition of this work appeared in 1951 the reviewer felt that while this was a book of quality which did not appreciably advance the state of knowledge in its particular field, yet it added a work of standing to those already available. That it is indeed a work of standing has been proven by its popularity, particularly amongst students coming newly to the field of control engineering. In some measure this can be attributed to the authors being senior members of the control engineering staff of the American General Electric Company and to their having lectured on the subject matter. They are thus well qualified to write in a manner which appeals to the student.

This second edition of Volume I exceeds the first edition in size by some 180 pages. Having in mind the rapid expansion of this branch of engineering, this new edition was examined with considerable interest to see to what use these additional pages had been put. On the whole the increase in size has been justified, the major part being due to an admirable account of the Root Locus methods of analysis and design. An 18 page section in Chapter 3 provides the first introduction to the ideas involved and lists a number of aids which can be used in the construction of root locii. The whole of Chapter 13 (some 60 pages) is devoted to the same subject ; this is a clearly written account and contains a number of numerical examples showing the manner in which this design technique may be used. Other small additions on this same subject are made at appropriate places in the text. These 90-odd pages materially enhance the value of the work.

The other major addition, contributed by W. E. Sollecito, is also entirely new to this book, dealing as it does with the fundamentals of analogue computers. Although such information is readily available elsewhere it does fit here and serves a useful purpose in introducing students to the application of this tool to the control engineering field. Whether the practising engineer will find this chapter of use is another matter. It also seems a pity to waste space on photographs of computers, photographs of less informative subjects surely do not exist. The other new pages are used to rewrite introductory sections to some of the chapters and to make minor alterations and additions.

The text is in the main excellently written, although there is a tendency in places to expand explanations to an unnecessary degree. It would be possible to achieve some compression with no loss of information. The only serious criticism that can be directed against the book concerns the nomenclature and symbols used, which are based, according to the authors' introduction, on the recommendations of ASA C-85. This usage leaves something to be desired when it results in notation such as that of the diagram of Fig. 10.1-18 on page 291. On this diagram R is used to symbolize not only the reference input to the system but also the resistances in a correcting network, while C stands for the controlled variable and for capacitance. Surely it is possible despite the limited extent of available alphabets to avoid such unhappy results. It may be argued that here no confusion exists, but is it not the logical conclusion to symbolize all components, whatever their nature, by C_1, C_2, C_3, etc., and all variables by V_1, V_2, V_3, etc. and to save the compositor a lot of trouble ?

These are nevertheless relatively minor drawbacks of an otherwise admirable work. Student and practising engineer alike should have this book. The student will find here an excellent textbook providing him with a very sound basic knowledge of control engineering. The engineer will find the work a source of information on many aspects of servomechanism design, for example the 36 charts which occupy the last 18 pages of chapter 15 provide this in a readily applicable form.

It is safe to predict that this book will long be known, not by its title, but as " Chestnut and Mayer ".

S. W. PUNNETT.

MODERN PHYSICS

By M. S. Smith

London: Messrs. Longmans, Green and Co. Ltd. Pp. ix + 254. Price 15s.

At a time when the American printing presses are turning out a spate of introductory University textbooks on modern physics, all good but almost indistinguishable from one another, it is pleasant to review an English book which is in many ways different. To start with, it is a much slimmer volume that will almost fit into a pocket and yet, with one exception to be mentioned later, it contains all it should. Then again, it is not really a textbook, or at least it would require an exceptionally brilliant student to pass any sort of examination on the strength of it. This is the fault of examinations, which always stress the importance of what is examinable and not of what is important. The book does not attempt to drown the reader in facts, but it makes him think.

The story of modern physics concerns itself not only with the discovery of new facts, but also with that of new concepts and ideas, and it is the latter that in my opinion comes primarily under " what is important ". To get a real grasp of this revolution of ideas one must understand the ideas that went before them and one must try and get an insight into the minds of the great men of the past, who were not just old fuddy-duddies who ought to have known better, as so many schoolboys seem to think. This the book does very well. However, when it turns to the new ideas, many of which are essentially of a mathematical nature, the treatment is less good. One may admire the dexterity with which the author skates round the difficulties of Minkowski four-space or the Schrödinger equation, but one is left with an uneasy feeling that sleight-of-hand is no substitute for rigour.

All this is not to say that the facts or even the apparatus of modern physics are neglected. Most of it is there and given its due importance, and the section on mass spectrometers is an object lesson in how to explain a piece of apparatus without introducing mathematical complexities which in this case add nothing to the understanding. It is a pity that three whole chapters are given to nuclear and sub-nuclear particles. Much of it is not fundamental, and what is, is only very imperfectly understood. On the other hand, a chapter on solid state physics is sadly lacking.

This is a good book, even if it is at times a little glib and gives the impression that there is little left that is in doubt. It is what physics is really about, a thing that the boy with his nose to the grindstones of A level and B.Sc. syllabuses so often misses. Even those of the other culture might tackle it with profit and if they did so, could scarce forbear to cheer.

L. R. B. ELTON.

SOLID STATE PHYSICS IN ELECTRONICS AND TELECOMMUNICATIONS : Proceedings of an International Conference held in Brussels, June 2-7 1958.

Edited by M. Desirant and J. L. Michiels.

Volume 3 : Magnetic and Optical Properties, Part 1.
Volume 4 : Magnetic and Optical Properties, Part 2.

Pp. xvi + 963. Prices : Volume 3. 128s. 6d. Volume 4. 114s. 6d. London : Academic Press Inc. Ltd.

The Brussels Conference in 1958 covered a wide range of topics in Solid State Physics, and in its applications to electronics and telecommunications. There was a large attendance, and there were several sessions running in parallel throughout most of the Conference. It is clearly impossible for any one delegate to assess the Conference as a whole, and in fact the amount of material in any one subject was probably too large to be digested on the spot. Publication of the proceedings is therefore useful, even for those who were able to attend, although the delay in publication has been longer than was anticipated. Some of the material, which was new in 1958, has been published elsewhere in the meantime; the value of the books is somewhat reduced by this.

Volume III deals with ferrites, the properties and applications of magnetic materials, yttrium iron garnets and magnetic resonance. The second of these sections includes microwave applications of ferrites, the ferromagnetic microwave amplifier, memory cores, and magnetic amplifiers. The last section includes important contributions on the absorption of infra-red in semiconductors in the presence of a magnetic field, and on paramagnetic and cyclotron resonance.

Volume IV commences with the related subject of masers, and continues with electroluminescence, phosphors, radiation damage, and some miscellaneous topics including ferroelectricity, alkali halides and selenium. The headings of the list of contents in this volume are incorrect after page 776, and confuse the section on radiation damage with that on miscellaneous problems. The papers on radiation damage include some basic work, together with studies of the effect of nuclear radiation on ferrites, ferromagnetic cores, and transistors. The papers on masers were of considerable importance in 1958, but their publication now illustrates the rapid progress in this subject. In contrast, the papers on electroluminescence and phosphors are not easily dated, which is consistent with the slow rate of progress in these subjects ; the paper on infra-red phosphors is, however, an exception to this.

D. A. WRIGHT.

PHYSICS FOR STUDENTS OF SCIENCE AND ENGINEERING PARTS 1 and 2

By R. Resnick and D. Halliday

London : John Wiley & Sons Inc. Pp. xiv+1025. Price 48s. each part; combined edition 84s.

It is to be expected that more and more books on fundamental science for engineering students will be published because naturally the modern trend in university engineering courses is to include more basic material at the expense of the older detailed treatment of specialized matters. The two present volumes are entitled *Physics for Students of Science and Engineering* and it is not my purpose to comment on the suitability or otherwise of whatever is meant in this context by "science students." Presumably this term includes students of chemistry, geology, biology, etc.

The general criticism I would make of the present volumes in relation to university engineering courses is that they are probably a little too elementary on various matters when more space could be devoted to more advanced physics. It is not easy to place them in relation to the usual syllabuses for engineering but they would appear to be appropriate for students in the first year, and possibly the beginning of the second year, in a three year university course, with certain reservations ; for example the electricity and magnetism content would not in all respects be suitable for students in electrical engineering and perhaps the same might apply for properties of matter for mechanical engineers.

The books have been written and prepared with the greatest care and attention to detail and their technical production is excellent. Volume 1 includes in general terms properties of matter, acoustics and heat and thermodynamics. The section on collisions is particularly interesting. Volume 2 includes electricity and magnetism, optics, and short chapters on quantum theory and wave mechanics. The latter subjects could with profit have been treated in more detail.

The main sections are on (Volume 1) properties of matter and (Volume 2) electricity and magnetism, and the treatment, although in my opinion rather too elementary, is very comprehensive.

The diagrams are interesting but some of them are too romantic even for engineers. Thus in Volume 1 Figure 9-7 shows a projectile exploding in the air as it follows its trajectory, and in my opinion unnecessary detail of this kind is distracting. Again Figure 10-1, showing a baseball bat striking a ball, is of some appeal but the caption states that the deformation of the ball suggests "enormous" impulsive force. This is scientifically inexact because clearly other variables, such as the softness of the ball should be considered. On the other hand, Figure 10-10 of trajectories in a Wilson chamber is extremely clear and gives a very good explanatory diagram, an unusual feature. Figure 15-19 showing the Tacoma Narrows bridge in process of disintegration is very striking and informative. In Volume 2 Figure 41-1 showing the reflection of refraction of an air/water interface is very good, although of course it considers a very elementary point.

Works of this kind almost invariably will be judged by reviewers from their own points of view and it would be interesting to learn the response of teachers of say biology to these volumes, which should certainly be commended for students needing instruction at this level.

J. D. Craggs.

PROGRESS IN METALLURGICAL TECHNOLOGY

Lectures delivered at the Institution of Metallurgists' Refresher Course 1959

London : Iliffe & Sons Ltd. Pp. vii+147. Price 32s. 6d.

At the 13th Refresher Course of the Institution of Metallurgists in 1959 four papers were presented :

Modern Developments in Iron and Steel Production, by Dr. J. Taylor.

Extraction and Refining of Non-Ferrous Metals, by Mr. A. V. Bradshaw.

Melting of Ferrous and Non-Ferrous Metals, by Dr. A. G. Robiette and

Casting of Ferrous and Non-Ferrous Metals, by Dr. D. V. Atterton.

At a time when much exciting work on metals is being done in laboratories and is directed to a deeper understanding of the physics of metals, these papers come as a reminder that many of the problems in metallurgy can only be solved by studying them in production and on a large scale, and that an enormous amount of patient technological work is involved. The evolutionary development that characterized the metal industry for hundreds of years has, during the past few decades, given way to many revolutionary changes in methods of extraction, casting and refining. Techniques that a few years ago were confined to laboratory experiments are now used for large scale manufacture, not only for the newer metals, but also for the commoner metals that are produced in large quantities. Modern engineering activities are making insistent demands for greater uniformity in the properties of metals, and these lectures survey what is being done to meet these demands economically.

All the papers maintain the excellent standard which has been set at the earlier Refresher Courses of the Institution. They will be of value and interest not only to the technologists engaged in the day-to-day activities of the metal industry, but also the many physicists and metallurgists engaged on research into the basic properties of metals.

G. W. Warren.

STATISTICS MANUAL

By Edwin L. Crow, Francis A. Davis, Margaret W. Maxfield

New York : Dover Publications Inc. Pp. xvii+288. Price $1.55

This manual was prepared for use at the Naval Ordnance Test station in California, and is now made available to a wider public, particularly engineers and scientists who need to use statistical procedures.

It is not a text-book but it is a clear and brief account of the fundamental techniques which might be used in analysing and testing data. There are many examples, often drawn from ordnance practice, to illustrate the various methods. It should be possible for the non-

specialist to follow the instructions with success, for the clarity of the exposition is remarkable. However, there is the wise warning " consult with a statistician while the experiment is being designed ".

The early chapters deal with the different common distributions, the tests for means and standard deviations, followed by an account of analysis of variance, regression, quality-control charts and sampling. The appendix contains some very useful tables.

J. TOPPING.

MECHANICS FOR TEXTILE STUDENTS

By W. A. Hanton

London: Butterworths Publications. Pp. x+336. Price 30s.

This book deals with the subject of mechanics at an elementary level, occasionally approaching but never exceeding that of an O.N.C. in Applied Physics or G.C.E. (A). Its interest lies in the very effective way in which the subject is related to the machines and processes of the textile industry. In particular, the book contains more than 200 numerical examples, each of which represents a realistic and relevant practical problem. I can well believe that the kind of student for whom it is intended will acquire from this book a sound grasp of the fundamentals of mechanics.

A. E. DE BARR.

THERMODYNAMIC TABLES AND OTHER DATA

Edited by R. W. Haywood

London : Cambridge University Press. Pp. 23. Price 2s. 6d.

This is the second edition of the volume first published in 1956. It contains some general data which are of use in thermodynamic calculations and short tables of gas data (mol. wt., density, specific heats, etc.) and calorific values.

The major portion of the tables are subdivided under two general headings :

(1) Steam tables (Nos. I to VII), and

(2) Refrigerant tables (Nos. IX to XII).

The steam tables give the thermodynamic properties of saturated water and steam, superheated steam, and compressed liquid water.

The refrigerant tables give the properties of common refrigerants, ammonia, carbon dioxide, Freon-12 and methyl chloride.

The tables are well set out and easy to use, and should prove extremely useful to the student.

R. G. SIDDALL.

Letters to the Editor

The Teaching of Physics in Schools

It is some years since I had to do any teaching of physics myself but I have learned much of the effects of such teaching in schools from having to mark hundreds of G.C.E. scripts yearly for over fifty years.

Without going so far as any complete rearrangement of the course such as was recently recommended it is clear to me that there is much room for change in the presentation of the existing syllabus and a good deal of room for change in the syllabus itself.

Pupils are not taught to think and I doubt whether the teachers themselves have ever given any real thought to the subject. Certain facts and formulae must be learned by heart.

Perhaps the worst chapter in the matter is that connecting an electric current with its interaction with a magnetic field. First either Ampere's or Maxwell's rule is learned, then it comes up again as Fleming's left and right hand rule and many schools produce a mysterious diagram in which the letters N and S are written at the ends of a solenoid. If this means anything it is a denial of the existence of a solenoidal field.

How much time is wasted in elementary mechanics in learning $s=\frac{1}{2}at^2$, etc. This is all very well for an elementary chapter on differential calculus but quite incomprehensible to a mind with no mathematical preparation. Moreover it has no practical usefulness. We do not spend our time throwing stones off cliffs though the wretched pupil gets the idea that these equations apply to some sorts of everyday motion. We pass on to $\frac{1}{2}mv^2$ with no connection with 2as; this is just another formula to be got by heart.

One could go through the whole syllabus selecting similar examples but I think that I have quoted enough to indicate my thesis that physics—even at school level—must be treated as a scientific subject and not as another form of " rep ".

The Old Shop,
Neat Enstone,
Oxford.

R. T. LATTEY (*F.Inst.P.*)

I have read, with much interest and a good deal of approval, the report in the *Bulletin* for September, 1960. Its emphasis on Physics as a part of modern culture, the need to show the difference between science and technology, its assertion that the fundamental problem in teaching science is to ensure the understanding of concepts, its stressing of the importance of the quality of mind of the teacher—all these must meet with approval. So, too, when it draws attention to the dangers of attaching too much importance to the achievement of accuracy and precision of observation at early stages, and when it warns against mechanics becoming an excuse for exercises in ingenious mathematics ; and when it points out the need for compromise, in practical work, between too much teacher-demonstration and the doctrinaire

concentration on class-experiments. But one aspect of the report alarms me—that " the introduction to Physics should be through a consideration of atoms, molecules and electrons ".

If this meant that the teacher should have this interpretation of the subject in mind constantly, and should so deal with his topics as to permit them being readily understood in terms of atomic, molecular and electronic hypotheses at an appropriate later stage—when further work demands such hypotheses and their use to explain earlier observations is proper—I would say that this is what many teachers do already. But we are told that " most children are *aware of the terms* and have at least *a vague idea* that matter consists of these entities " and therefore a teacher may begin " by building upon the children's interest ". Fine foundations for a branch of culture !

The terms atom, molecule, electron, wave, energy, are meaningless nouns, referring to concepts of which children can have no direct experience, and are indefensible at the start of a grammar school course (the report concentrates its attention on the top 15-20% of the ability range) and until there is some basis for them from elementary electrostatics experiments, electrolysis, quantitative experiments in chemistry and a study of experiments in which the effects of waves are observable as such. Those who are capable of understanding such a basis for the concepts should not be allowed to rely on them without it ; those who are not capable of understanding such a basis will derive no benefit, either cultural or practical, from being given a list of them at the start.

Items (*d*) to (*h*) in the outline of the course, including such topics as laws of thermodynamics, thermionics, electromagnetic vibrations, light as electromagnetic radiation, emission and absorption of light, simple ideas of quantum theory, emission of X-rays, structure of the nucleus, elementary introduction to relativity, leave room for much speculation as to what part of this will be cultural and educative, and what part will be technological and a matter of mere instruction. Perhaps we should await the textbook proposed in support of the suggested course : but Heaven defend me from anything which begins to resemble a nationally prescribed textbook (unless it be one I have written myself !).

Examinations attract some comment and criticism. I think it should be recognized that both the syllabuses and the style of questions set in Physics by some boards have shown a very enlightened approach in the last half dozen years. But even questions designed to diagnose ability (at S level) and test understanding (at A level) must depend on some basis of memorized information and standard formulae. It is to be regretted that the authors of the report " see no virtue at this stage in holding practical examinations ". Even those who feel the examinations have no diagnostic value must surely admit that their existence encourages practical work and familiarity with instruments, and encourages the supply of apparatus for these purposes.

I will admit to being in the category of middle-aged, or nearly so, depending on definitions ; I defy attempts to classify me as an " educator " or as one primarily interested in my specialist subject ; I bar from my teaching no modern topic, known to me, or of which my class can inform me, provided it can be considered in the light of known phenomena, theories and principles which have been acquired by methods which can be called education and not instruction: but I will not base my teaching on *revelation* of a set of models and notions which could be subsequently reached by ways which would be intellectually satisfying to my pupils.

C. B. SPURGIN (*A.Inst.P.*)
Wolverhampton Grammar School,
Compton Road, Wolverhampton.

Mr. N. Clarke, as Chairman of the Committee that produced the report, comments:

I do not think I need discuss Mr. Spurgin's alarm in any detail. I am content to let the report speak for itself.

What Mr. Spurgin seems to ignore is the clear statement that the report is " concerned essentially with the basic approach of the teacher and with his appreciation of what are the fundamentals of physics " —in other words, with the spirit in which physics is taught. The committee was not trying to add one more immutable, externally-imposed syllabus to the several from which Mr. Spurgin may already choose for the examination of his students. Fortunately there are many teachers of physics, in this and other countries, who welcome new suggestions of ways by which we may teach physics so that it will be meaningful to children who do not make a specialist study of it.

Incidentally, it is to me odd—and regrettable—that a teacher should sneer at the suggestion, which some of us had regarded as rather obviously sound educationally, that a good teacher would make use of the child's interests.

Finally, I was depressed when I read Mr. Spurgin's remarks on practical examinations. It may be true, as he implies, that physics teachers will devote time to practical work only if there is to be a practical examination at the end, but if this is so it would seem to me to be all the more urgent that we—and Her Majesty's Inspectors—should give some serious attention to " the basic approach of the teacher."

The report has been extremely well received here and abroad and is to be reprinted in the January issue of the American *Physics Today*. Reprints have been requested from all over the world and with very few exceptions, comments have been most warmly in favour of the suggestions made and, above all, of the spirit in which the report is written.

I have, however, been asked by one or two teachers whether any of the seven members of the committee had had experience of teaching in schools. It is, of course, rather sad that such information can be requested, the implication of the request being clear enough. One might have hoped that physicists could have treated a report simply on its merits. However, M. Renaud is a practising school teacher in Switzerland, of long experience ; Professor Sikjaer was until recently the headmaster of a school in Copenhagen, has taught physics in schools for twenty-five years and is the author of several physics textbooks for schools; Professor Michels was a school teacher for fifteen years at the beginning of his career.

N.C.

Forthcoming Institute and Society Meetings

THE following is the list of Institute and Society meetings so far arranged for the second half of the 1960-1961 session. In some cases arrangements are provisional. **Fuller details of each meeting will be sent in due course to the members of the Branch or Group concerned** and may be obtained by other members of the Institute and Society on application to the Secretary. Where it is indicated that registration is necessary early application should be made

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Jan. 10 to 12	**Bristol** The University		Conference on **The physics of polymers**		
Jan. 11	**London** Headquarters	Professor R. E. Peierls, C.B.E., F.R.S. (*University of Birmingham*)	**Teaching mathematical physics**	5.30 p.m.	Education
Jan. 12	**Liverpool** The University	Mr. S. Rees Jones F.Inst.P. (*Courtauld Institute of Art, London*)	**Physics and painting**	7.00 p.m.	Liverpool and North Wales
Jan. 13	**London** "Horseshoe Hotel"	Mr. Thorold G. Jones (*Atomic Energy Research Establishment, Harwell*)	Dinner meeting followed by an informal address on **Gem stones**		Non-Destructive Testing
		Tickets are necessary.			
Jan. 16	**Manchester** College of Science and Technology	Dr. J. M. A. Lenihan, F.Inst.P. (*Western Regional Hospital Board, Glasgow*)	**Physics and physic**	7.00 p.m.	Manchester and District
Jan. 16	**Edinburgh** The University	Mr. C. A. Taylor, F.Inst.P. (*College of Science and Technology, Manchester*)	**Optical transform techniques**	7.15 p.m.	Scottish
Jan. 16 to 20	**London** Royal Horticultural Society's Halls		**45th Exhibition of scientific instruments and apparatus**		
		Admission is by ticket only, available from The Secretary			
		Exhibition discourses:			
Jan. 17	**London**	Mr. F. S. Burt	**Hydrodynamic research**	5.45 p.m.	
Jan. 18	Royal Horticultural Society's Halls	Dr. G. E. R. Deacon, F.R.S.	**Physics of the oceans**	5.45 p.m.	
Jan. 19		Dr. F. P. Bowden, F.Inst.P., F.R.S.	**Some physical problems in travelling at supersonic speed**	5.45 p.m.	
		Admission is by Exhibition ticket.			
Jan. 17	**Glasgow** The University	Mr. C. A. Taylor, F.Inst.P. (*College of Science and Technology, Manchester*)	**Optical transform techniques**	7.15 p.m.	Scottish
Jan. 17	**London** Headquarters	Professor G. W. Hutchinson (*University of Southampton*)	**Some recent developments in particle detectors**	5.30 p.m.	Electronics
Jan. 18	**Dundee** Queen's College	Mr. C. A. Taylor, F.Inst.P. (*College of Science and Technology, Manchester*)	**Optical transform techniques**	5.30 p.m.	Scottish
Jan. 18	**Birmingham** Dunlops Ltd.		Visit to factory and laboratories followed by a talk	2.00 p.m.	Midland
		Registration is necessary.			
Jan. 18	**London** Headquarters	Dr. R. W. Hill (*Clarendon Laboratory, Oxford*)	Group Annual General Meeting followed by a lecture on **The thermodynamic properties of fluid helium**	4.00 p.m.	Low Temperature
Jan. 18	**London** Royal Horticultural Hall	Dr. D. W. Robinson (*National Physical Laboratory, Teddington*) Mr. C. H. G. Mills (*Motor Industry Research Association*) Miss S. Fogarty (*Ministry of Transport*)	Symposium on **Traffic noise**	2.30 p.m.	Acoustics
Jan. 20	**Newport** Newport and Monmouthshire College of Technology	Dr. A. P. Willmore (*University College, London*)	**Astronomical observations from rockets and satellites**	6.15 p.m.	South Wales

Date	Place	Speaker	Title and other details	Time	Branch or Group
Jan. 20	**Bristol** College of Science and Technology	Mr. G. W. Warren, M.B.E., F.Inst.P.	**The physicist and the technologist in industry**	7.00 p.m.	Western
Jan. 23	**London** Headquarters	Dr. E. Eastwood (*Marconi Instruments, Great Baddow*)	**Some new applications of radar**	6.00 p.m.	London and Counties
Jan. 25	**Durham** Science Laboratories	Dr. E. Mendoza (*University of Manchester*)	**Superconducting circuitry**	5.30 p.m.	North Eastern
Feb. 2	**London** Imperial College	Dr. J. H. Sanders, A.Inst.P. (*University of Oxford*)	**Atomic physics in the modern spectral lines** **Optical masers**	2.30 p.m.	Optical
Feb. 6	**Edinburgh** The University	Dr. R. L. Woolley, F.Inst.P. (*Central Electricity Generating Board, London*)	**The physicist in the electricity generation industry**	7.15 p.m.	Scottish
Feb. 7	**London** Headquarters		**Tunnel diodes**	2.30 p.m.	Electronics jointly with British Institution of Radio Engineers
Feb.	**Glasgow** The University	Dr. R. L. Woolley, F.Inst.P. (*Central Electricity Generating Board, London*)	**The physicist in the electricity generation industry**	7.15 p.m.	Scottish
Feb. 8	**Sheffield** The University	Mr. A. E. S. Pengelly, A.Inst.P. (*United Steel Co. Ltd., Rotherham*)	**Physical principles applied to the design and operation of furnaces**	5.00 p.m.	Yorkshire
Feb.	**London** Headquarters	Professor A. B. Pippard, F.R.S. (*Royal Society, Mond Laboratory, Cambridge*)	**Ultrasonic absorption and attenuation in metals at low temperature** followed by short original contributions	2.30 p.m.	Low Temperature
Feb.	**Liverpool** The University		**Specialization in schools and university**		
Feb. 10	**London** Headquarters	Dr. R. W. Powell, F.Inst.P. (*National Physical Laboratory, Teddington*)	**Applications of thermal conductivity**	6.30 p.m.	Non-Destructive Testing
Feb. 10	**London** Headquarters	Mr. L. Ward, A.Inst.P. (*Pilkingtons Ltd.*, Mr. G. L. Mason (*United Steel Co. Ltd., Rotherham*)	**The analysis of non-metallic materials by emission direct reading methods**	2.00 p.m.	Applied Spectroscopy
Feb.	**Birmingham** Birmingham Exchange and Engineering Centre	Dr. J. Darbyshire, F.Inst.P. (*National Institute of Oceanography, Wormley, Surrey*)	**Sea waves and microseisms** **Soil**	6.30 p.m.	Midland
Feb. 17	**Cheltenham** North Gloucestershire Technical College	Mr. D. F. Gibbs, A.Inst.P. (*University of Bristol*)	**Physics of musical instruments**	7.00 p.m.	South Western
Feb. 20	**Edinburgh** The University	Dr. [illegible] (*United Kingdom Atomic Energy Authority, Harwell*)	**Magnetic susceptibility of transition metal alloys**	7.15 p.m.	Scottish
Feb. 20	**Feltham** National Physical Laboratory, Ship Hydrodynamics Laboratories	Mr. J. R. Shearer,	**Dynamometer techniques used in**		Stress Analysis
Feb. 20	**Newcastle-upon-Tyne** King's College	Dr. J. [illegible], F.Inst.P. (*University of Durham*)	**Thunderstorm [illegible] protons**	6.15 p.m.	North Eastern

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Feb. 20	**Manchester** The University		Branch Annual General Meeting followed by a lecture on	6.30 p.m.	Manchester and District
		Dr. L. Essen, O.B.E., F.R.S. (*National Physical Laboratory, Teddington*)	**Some misconceptions concerning the special theory of relativity**	7.00 p.m.	
Feb. 21	**Glasgow** The University	Dr. W. M. Lomer (*United Kingdom Atomic Energy Authority, Harwell*)	**Magnetic susceptibility of transition metal alloys**	7.15 p.m.	Scottish
Feb. 23	**London** Headquarters		Branch Annual General Meeting followed by a lecture on	2.30 p.m.	London and Home Counties
		Mr. B. C. Browne (*University of Cambridge*)	**The earth's gravitational field**		
Feb. 24	**Cardiff** University College	Professor J. Rotblat, F.Inst.P. (*Medical College of St. Bartholomew's Hospital, London*)	**Nuclear physics in medicine**	6.15 p.m.	South Wales
Mar. 2	**London** Imperial College	Mr. A. E. Crawford (*Brush Crystal Co. Ltd., Southampton*)	**Zirconate-titanate materials for ultrasonic transducers**	5.30 p.m.	Acoustics
Mar. 2	**London** Institute of Marine Engineers	Speakers to be announced later	**Problems of thermal insulation and their solution**	2.00 p.m.	Low Temperature jointly with the Institute of Refrigeration
Mar. 2	**Leeds** The University		Branch Annual General Meeting followed by a lecture on	7.30 p.m.	Yorkshire
		Professor J. D. Bernal, F.Inst.P. F.R.S., (*Birkbeck College, London*)	**Geometrical aspects of physical theories**		
Mar. 4	**Manchester** Grammar School	Introduced by Lord James (*Manchester Grammar School*), and Mr. A. D. C. Peterson (*University of Oxford*)	Discussion on **specialization at school** including a tour of Manchester Grammar School	10.00 a.m.	Education jointly with Manchester and District
Mar. 9	**Liverpool** The University	Dr. N. B. Slater (*University of Leeds*)	**Fundamental theory**	7.00 p.m.	Liverpool and North Wales
Mar. 10	**Bristol** The University	Professor O. R. Frisch, F.R.S. (*University of Cambridge*)	**The conservation laws of modern physics**	7.00 p.m.	South Western
Mar. 10		Lecture and details to be announced later			Non-Destructive Testing
Mar. 14	**London** Headquarters		Group Annual General Meeting followed by a lecture on	5.30 p.m.	Electronics
		Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	5.40 p.m.	
Mar. 15	**London** Beveridge Hall		Symposium on **Soil**	2.30 p.m.	London and Home Counties jointly with the Royal Institute of Chemistry and the Institute of Biology
		Registration is necessary.			
Mar. 16	**London** Headquarters		Group Annual General Meeting followed by lectures on	2.30 p.m.	Optical
		Mr. D. G. Demaine (*Hilger & Watts Ltd.*)	**The use of very fast digital computers in optical analysis and correction**		
		Dr. A. Goodman (*Birmingham College of Advanced Technology*)	**A theory of differential analysis for the correction of optical systems**		
Mar. 17	**Swansea** University College	Dr. R. A. Smith (*Royal Radar Establishment, Malvern*)	**Recent advances in physics of semiconductors**	5.15 p.m.	South Wales
Mar. 20	**Manchester** College of Science and Technology	Professor B. H. Flowers (*University of Manchester*)	**The structure of neutrons and protons**	7.00 p.m.	Manchester and District

Date	*Place*	*Speaker*	*Title and other details*	*Time*	*Branch or Group*
Mar. 21	**Glasgow** The University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	7.15 p.m.	Scottish
Mar. 21	**Newcastle-upon-Tyne** King's College	Dr. P. B. Hirsch, A.Inst.P. (*University of Cambridge*)	**Electron microscope studies of dislocations in metals**	6.15 p.m.	North Eastern
Mar. 22	**Birmingham** James Watt Memorial Institute	Dr. J. H. Davis, F.Inst.P. (*Bradford Institute of Technology*)	**Electronic reading machines**	6.30 p.m.	Midland
Mar. 22	**St. Andrews** St. Salvator's College, St. Andrews University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	5.00 p.m.	Scottish
Mar. 23	**Aberdeen** The University	Dr. O. S. Heavens, F.Inst.P. (*Royal Holloway College, London*)	**Optical masers**	7.45 p.m.	Scottish
April	**Spring Visit**				London and Home Counties
April 5 to 7	**London** Brunel College of Technology		Symposium on **Electrical contacts**		
		Registration for this Symposium is necessary.			
April 6 and 7	**London** Headquarters		Conference on **Communication; Physics for the non-specialist**	10.00 a.m.	Education
		Registration is necessary.			
April 6	**London** Headquarters		Group Annual General Meeting	5.15 p.m.	Education
April 6 and 7	**Glasgow** The University		Group Annual General Meeting and Spring Conference on **The crystal structures of organic compounds**		X-ray Analysis
		Registration is necessary.			
April 7		Lecture and details to be announced later			Non-Destructive Testing
April 12	**Birmingham** Birmingham Exchange and Engineering Centre	Papers presented by two student members	**Students' Evening**	6.30 p.m.	Midland
April 12	**London** Headquarters		**Generation of high magnetic fields for cryogenic purposes**	2.30 p.m. (or possibly all day)	Low Temperature
April 13	**Liverpool** The University	Dr. G. B. F. Niblett (*Atomic Weapons Research Establishment, Aldermaston*)	**Experiments on rapid magnetic compression of a plasma**	7.00 p.m.	Liverpool and North Wales
April 13		Subject, speaker, place and time to be announced			Acoustics
April 14	**London** Headquarters	Mr. D. H. Peirson, F.Inst.P. (*United Kingdom Atomic Energy Authority, Harwell*)	**Gamma-ray spectrometry**	2.30 p.m.	Applied Spectroscopy
April 16 to 18	**Birmingham** The University		**Nuclear physics conference** Registration for this conference is necessary. Programs and application forms are available from the Honorary Conference Secretary, Department of Physics, The University, Edgbaston, Birmingham, 15.		
April 21	**Birmingham** Students' Union, The University		Annual Branch Dinner		Midland
April 21	**Aberystwyth** University College	Dr. G. R. Evans, Grad.Inst.P. (*University of Edinburgh*)	**European co-operation in nuclear research**	5.15 p.m.	South Wales
April 24 to 28	**Southampton** The University		Annual Conference on **The mechanism of rupture**		Stress Analysis
		Registration is necessary.			

Date	Place	Speaker	Title and other details	Time	Branch or Group
May 2	**London** The Royal Commonwealth Society		The 21st Anniversary of the establishment of the amalgamated body will be marked by a Presidential Address. Admission by ticket Further details will be circulated in due course	5.00 p.m.	Glasgow
	London Park Lane Hotel		**Annual Dinner of the Institute and Society**	7.30 p.m.	
May 4	**London** Imperial College	Mr. E. W. H. Selwyn, F.Inst.P. (*Kodak Ltd., London*) Mr. K. H. Birch (*Imperial College*) and other contributors	**Spatial frequency response as a criterion of the performance of optical systems** Discussion meeting on	2.30 p.m.	Optical
May 10	**London** Headquarters	Mr. M. Zvegintzov (*National Research Development Corporation*)	**The future of deep low temperature engineering**	4.00 p.m.	Low Temperature
May 11	**Liverpool** The University	Professor J. M. Cassels, F.R.S. (*University of Liverpool*)	**Fundamental particles**	7.00 p.m.	Liverpool and North Wales
May 11		Dr. D. Kleis (*Philips Electrical Industries, Eindhoven*)	**Ambiophony** Place and time to be announced.		
May 12		Lecture. Details to be announced later			Non-Destructive Testing
May 15	**London** Headquarters		Half-day symposium on **Recent advances in resistance strain gauge techniques** Registration is necessary	2.30 p.m.	Stress Analysis
May 18	**Malvern** Royal Research Establishment		Visit to Royal Radar Research Establishment, followed by a talk Registration is necessary	2.00 p.m.	Midland
June			**Summer Meeting**		London and Home Counties
June 1	**London** Imperial College	Mr. K. Hacking (*B.B.C. Research Laboratories*)	**Secondary flare in lenses**	2.30 p.m.	Optical
June 8	**London** Imperial College		Symposium on **Medical acoustics**		Acoustics
June 16	**Manchester**	Speakers and title to be arranged	**Uses of spectroscopy in the study of discharges**		Applied Spectroscopy
June 30	**Winfrith** Atomic Energy Establishment		Summer Meeting — Visit to Atomic Energy Establishment Registration is necessary		South Western
July 10 and 11	**Durham** The University		Symposium on **Thermoelectricity** Registration is necessary		
July 10 to 14	**London** Imperial College		Conference on **Optical instruments and techniques** (arranged under the auspices of the International Commission for Optics by The British National Committee for Optics)		Optical
July 10 to 14	**Nottingham** The University		Annual Conference Registration is necessary		Electron Microscopy
July 19	**Camden Town and Debden**		**All day visit to Hilger & Watts Ltd. factories** Registration is necessary.		Education

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE COUNCIL ON DECEMBER 6, 1960

An asterisk (*) indicates transfer from another grade

FELLOWSHIP of The Institute of Physics (11)

*Brown, Cyril Simon, B.Sc., Group Leader, The General Electric Co. Ltd., Research Laboratories, Wembley, Middx.

*Bovey, Leonard B. A., Ph.D., Principal Scientific Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

*Button, James Charles Ezekiel, B.Sc., Health Physics Adviser to the Government of Thailand.

Campbell, Clifford Graham, B.Sc., M.A., Ph.D., Senior Principal Scientist, Atomic Energy Establishment, Winfrith, Dorset.

*Cook, Peter Mordaunt, B.Sc., Research Manager, J. J. Habershon & Sons Ltd., Rotherham, Yorks.

Goldsmid, Hiroshi Julian, B.Sc., Ph.D., Senior Scientific Staff, The General Electric Co. Ltd., Research Laboratories, Wembley, Middx.

*Hilsum, Cyril, B.Sc., Ph.D., Group Leader, Admiralty Research Laboratory, Baldock, Herts.

*Lonsdale, Dame Kathleen, D.Sc., F.R.S., Professor of Chemistry, University College, London.

*McNeill, Donald Burgess, M.Sc., Ph.D., Lecturer in Physics, University of Southampton.

*Power, Geoffrey, M.A., Ph.D., Senior Lecturer, Mathematics Department, University of Nottingham.

Weaver, Charles, B.Sc., Lecturer, Royal College of Science and Technology, Glasgow.

ASSOCIATESHIP of The Institute of Physics (46)

*Axson, Michael, B.Sc., Senior Research Officer, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester.

*Badzioch, Stanislaw, B.Sc., Research Physicist, Combustion Department, British Coal Utilization Research Association, Leatherhead, Surrey.

*Brown, Ian David, B.Sc., Ph.D., Postdoctorate Fellow, McMaster University, Hamilton, Ontario, Canada.

Bullough, Ronald, B.Sc., Ph.D., Theoretical Physicist, Associated Electrical Industries Research Laboratory, Aldermaston Court, Aldermaston, Berks.

*Budworth, David Wolstenholme, B.Sc., Ph.D., Research Assistant, Ceramics Division, Houldsworth School of Applied Science, University of Leeds.

*Bunn, John Peter, M.Sc., Lecturer, Lanchester College of Technology, Coventry.

*Carew-Jones, John, B.Sc., Master in charge of Physics, Llandovery College, Carms.

Chapman, Kenneth Reginald, M.Sc., Senior Research Associate, University of Birmingham.

*Clark, John Leslie, B.Sc., Ph.D., Senior Lecturer, Sunderland Technical College, Co. Durham.

*Clemson, Colin Spencer, B.Sc., Technical Officer, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester.

*Davison, Louis, B.Sc., Development Engineer, United Steel Co. Ltd., Rotherham, Yorks.

*Dollimore, John, M.Sc., Assistant Lecturer, The Royal Technical College, Salford, Lancs.

*Dove, Geoffrey Thomas, B.Sc., Scientific Staff, The General Electric Co. Ltd., Research Laboratories, Wembley, Middx.

*Downing, Gerald Thomas, B.Sc., Lecturer, North Gloucester Technical College, Cheltenham, Gloucester.

Edgar, John, B.Sc., Lecturer, Dundee Technical College.

Edwards, Brian Philip, M.Sc., Assistant Lecturer, Bristol Technical College.

Funk, Josef Peter, D.Phil., Research Officer, C.S.I.R.O., Victoria, Australia.

Golden, John, B.Sc., Ph.D., Health Physicist, Central Electricity Generating Board, Bradwell.

*Grodszinsky, Ernest Juergen, B.Sc., Head of Applications Laboratory, Electronic Tubes Ltd., London.

*Hindley, Tony Kenneth Derrick, B.Sc., Senior Engineer, Blackburn Aircraft Co., Hull.

Holt, Peter Dudley, M.A., Scientific Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Jones, Vernon Graham, B.Sc., Assistant Lecturer, Gloucester Technical College, Gloucester.

King, Raymond John, M.Sc., Ph.D., Senior Scientific Officer, Light Division, National Physical Laboratory, Teddington, Middx.

Lale, Peter Gilbert, B.Sc., Ph.D., Senior Physicist, Guy's Hospital, London.

McCourty, William Donald, B.Sc., Chief Project Engineer, H.M. Hobson Ltd., Wolverhampton.

McKeague, Roddie, B.Sc., Ph.D., Physicist/Reactor Manager, U.K. Atomic Energy Authority, Chapelcross Works, Dumfriesshire.

*McTernan, Allen James, M.Sc., Lecturer, The Polytechnic, London.

Marsden, Kenneth Hulme, M.Sc., Lecturer, School of Applied Physics, University of New South Wales, Australia.

*Mendoza, Alfred Maurice, B.Sc., Physicist, Ministry of Aviation, London.

Menzies, David Campsie, B.Sc., Ph.D., Scientific Officer, U.K. Atomic Energy Authority, Dounreay, Thurso, Caithness.

Milne, John Gilbert Cockcroft, B.A., Ph.D., Lecturer, University of Sheffield.

*Payne, William Raymond, B.Sc., Senior Physicist, The General Electric Co. Ltd., Applied Electronics Laboratories, Stanmore, Middx.

Pywell, Richard Francis, B.Sc., Physicist, British Petroleum Co. Ltd., Sunbury-on-Thames, Middx.

*Richards, John Phillip Gerald, B.Sc., Ph.D., Assistant Lecturer, University College, Cardiff.

*Rowan, David, Senior Physicist, Western Regional Hospital Board, Regional Physics Department, Glasgow.

Ruffle, Warwick Owen, B.Sc., Science Adviser, Middlesex County Council Education Committee, London.

*Sammons, William Albert, B.Sc., Scientist, National Coal Board, Mining Research Establishment, Isleworth, Middx.

*Sinclair, Thomas Craig, B.Sc., Reactor Physicist, Central Electricity Generating Board, Nuclear Health and Safety Branch, London.

*Spiller, Robert Harold, B.Sc., Head of Non-Biological Sciences Department, Lordswood Girls' Grammar-Technical School, Birmingham.

Stanier, Harold Meredith, M.A., Ph.D., Section Leader, Imperial Chemical Industries Ltd., Widnes Laboratory, Lancs.

Stoney-Smith, Arthur Richard, B.Sc., Vice-Principal and Director of Studies, Stafford House Tutorial College, London.

Thornton, Edward, B.Sc., Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Williams, Frederick George, B.Sc., Senior Physicist, British Oxygen Research and Development Ltd., London.

Williamson, David Conway, M.A., Development Engineer, Electrothermal Engineering Ltd., London.

*Wilmore, James Robinson, B.Sc., Scientific Staff, The General Electric Co. Ltd., Applied Electronics Laboratories, Stanmore, Middx.

Wootton, Roy Edwin, B.Sc., Scientific Officer, British Insulated Callendars Cables Ltd., London.

GRADUATESHIP of The Institute of Physics (59)

Barnes, Donald John, M.Sc., Research Student, Imperial College, London.

*Beresford, John, B.Sc.Tech., Research Physicist, The Geigy Co. Ltd., Middleton, Nr. Manchester.

*Bevan, John Stuart, B.A., Technical Assistant, U.K. Atomic Energy Authority, Sellafield, Cumberland.

Boustead, Ian, B.Sc., Assistant Physics Master, William Hulme's Grammar School, Manchester.

Brown, Bevil Vernon, B.Sc., Deputy-Head of Research and Development Dept., George Wimpey Ltd., Southall, Middx.

Bruce, Robert Harding, B.Sc., Research Student, University of Manchester.

*Burrage, Peter Michael, B.Sc.Tech., Development Engineer, Transitron Electronic Corporation, Wakefield, Mass., U.S.A.

Cundall, John Allan, B.Sc., Physicist, Mullard Research Laboratories, Salfords, Surrey.

*Davies, Peter Gwynne, B.Sc., Research Student, University College of Swansea, Glam.

*Davis, Graham Noel, B.Sc., Research Assistant, Woolwich Polytechnic, London.

*Dyer, Donald, B.Sc., Technical Assistant, Broken Hill PTY Co. Ltd., New South Wales, Australia.

*Dyson, David John, B.Sc., Scientific Staff, The General Electric Co. Ltd., Research Laboratories, Wembley, Middx.

Edwards, Michael, B.Sc., Research Student, University of Liverpool.

Essam, John William, B.Sc., Research Student, King's College, London.

Evans, Geoffrey Boothby, B.Sc., Research Student, University College of North Staffordshire.

*Fletcher, John, B.A., Research Student, University College of North Staffordshire.

Frewin, Peter Davidson, B.Sc., Research Student, St. Bartholomew's Hospital Medical College, London.

Gant, Brian Edward, B.Sc., Assistant Master, Wandsworth School, London.

Gaskell, Waryn Thomas Mogridge, B.Sc., Technical Scientific Officer, Armament Research Development Establishment, Fort Halstead, Kent.

Hargreaves, Roger Alan, B.Sc., Physics Master, Queen Elizabeth's Grammar School, Blackburn, Lancs.

*Harris, Frank Martin, B.Sc., Research Student, University College of Swansea, Glam.

Harvey, Anthony Theo, B.Sc., Trials Engineer, De Havilland Aircraft Co. Ltd., Stevenage, Herts.

Hodgson, Peter Barrie, B.Sc., Courtaulds Research Scholar, University of Leeds.

Houghton, John, B.Sc., Graduate Apprentice, Electric and Musical Industries Ltd., Hayes, Middx.

*Ireland, John Vaughan, B.Sc., Research Student, University College, London.

*Irving, Valerie Jean, Junior Engineer, Electric and Musical Industries (Electronics) Ltd., Feltham, Middx.

Jones, David Lloyd, B.Sc., Research Student, University of Exeter.

Jones, John David, B.Sc., Physicist, Rolls Royce and Associates Ltd., Derby.

Kay, Robert Anthony Smedley, B.Sc., Technician, A. V. Roe & Co. Ltd., Manchester.

Litt, John, B.Sc., Research Student, University of London.

Lofthouse, John Herbert, B.Sc., Student, Department of Mining, University of Leeds.

McLaggan, James Roy, B.Sc., Development Physicist, Pilkington Brothers Ltd., St. Helens, Lancs.

Moore, Telford, B.Sc., Assistant Master, Holme Valley Grammar School, Huddersfield, Yorks.

*Morgan, Brian Augustus Llewelyn, B.Sc., Shift Assistant Technical Officer, British Nylon Spinners Ltd., Doncaster.

Mourant, Jennifer de Boyne, B.Sc., Information Assistant, Research Laboratory, Associated Electrical Industries (Rugby), Ltd., Rugby, Warwicks.

Paix, David, M.Sc., Experimental Officer, Commonwealth Experimental Building Station, Sydney, Australia.

Partridge, Roger Hugh, B.Sc., Graduate Demonstrator/Research Student, Royal Military College of Science, Shrivenham, Wilts.

Pearson, Alan Wilfred, B.Sc., Head of Fuel Analytical Section, Pilkington Brothers Ltd., St. Helens, Lancs.

Phillips, Dorothy Ann, B.Sc., Physicist, Atomic Power Constructions Ltd., London.

*Pittaway, Lawrence Graham, B.Sc., Physicist, Mullard Research Laboratories, Salfords, Surrey.

*Rees, David Brian, B.Sc., Research Student, University College of Swansea, Glam.

*Roberts, John Brian Griffith, B.Sc., Research Student, University College of Swansea, Glam.

*Robertson, Inge, B.Sc., Research Assistant, School of Chemistry, University of Leeds.

Rumsey, Kenneth George, B.Sc., Junior Engineer, Plessey Co. Ltd., Ilford, Essex.

*Scott, Diana Elizabeth, B.Sc., Assistant Physicist, Medical Physics Department, Royal Perth Hospital, Australia.

*Sherrin, Alan John, B.Sc., Physicist, Dunlop Rubber Co. Ltd., Birmingham.

Skelton, John, B.Sc., Graduate Apprentice, Smith's Aircraft Instruments, Cheltenham, Glos.

Smith, Francis Skillen, B.A., Junior Development Engineer, Hilger & Watts Ltd., London.

Smith, Malcolm Alfred, B.Sc., Assistant Experimental Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Smith, Robert Taylor, B.Sc., A.R.C.S., Research Student, Imperial College, London.

Speight, David Leighton, M.Sc., Physics Division, Central Electricity Generating Board, Berkeley, Glos.

Strange, John Harvey, B.Sc., Research Student, University of London.

Stanley, Gordon, B.Sc., Assistant Lecturer, Longton Technical School, Longton, Stoke-on-Trent, Staffs.

Tobin, Roderick Charles, B.Sc., Experimental Officer, Aeronautical Research Laboratories, Department of Supply, Victoria, Australia.

*Yeadon, Edward Christopher, B.Sc.Tech., Research Student, The Manchester College of Science and Technology.

Whitehouse, David J., B.Sc., Graduate Apprentice, Contractor Switchgear Ltd., Wolverhampton.

Whitehouse, Joseph Colin, B.Sc., Graduate Apprentice, Contractor Switchgear Ltd., Wolverhampton.

Willets, Francis Wilding, Dip.Tech., Research Physicist, Research Laboratory, Kodak Ltd., Harrow, Middx.

Whitaker, Malcolm Christopher, B.Sc., Technical Assistant, U.K. Atomic Energy Authority, Chapelcross Works, Dumfriesshire.

FELLOWSHIP of The Physical Society (10)

Brown, Michael Richard, B.A., Research Student, University of Oxford.

Dijkstra, H., D.Sc., Head of Physics Department, Staatsmijnen in Limburg, Geleen, Netherlands.

Dowson, Anthony Edward Kennеth, B.A., Research Student, University of Oxford.

Ellison, Robert John, B.Sc., Research Fellow, University of Manchester.

Foges, George, D.Sc., Consulting Physicist and Engineer, Gherzi Eastern Private Ltd., Bombay.

Ganguly, Satish Chandra, M.Sc., D.Phil., Reader in Physics, Jadavpur University, Calcutta, India.

Giere, Albert C., M.Sc., Research Physicist, University of New Mexico, Albuquerque, U.S.A.

Hewson, Alexander Cyril, B.A., Research Student, University of Oxford.

Khan, M. Aslam, M.Sc., Ph.D., Reader in Physics, University of Karachi, Pakistan.

Lines, Malcolm Ellis, B.A., Research Student, University of Oxford.

Sixty-seven Students and four Subscribers were also admitted.

Manuscripts accepted for publication in the Institute and Society's periodicals

In future, instead of publishing abstracts of papers appearing in the *current* issues of the *British Journal of Applied Physics* and the *Journal of Scientific Instruments* as has been done in the past, we shall publish the abstracts of papers which have been accepted up to the date of going to press. It will be a few months before the lists can be up-to-date; the following abstracts are of papers accepted up to the end of October.

British Journal of Applied Physics

Improvements of photoelastic technique for strain measurement on flat surfaces. By G. Clyne, H. Fessler and R. W. Wilson.
The use of the impact glue, Eastman 910, produced stronger bonds than could be achieved with epoxy resin adhesives. Epoxy resin layers bonded on to flat polished Dural surfaces were torn by fatigue cracks in the metal without extensive bond failure. The bond strength was improved by controlled etching and hot soaking of the Dural surface before bonding. Impact glue bonds between epoxy resin layers and flat polished alloy steel surfaces withstood static strains of 0·3% (slightly beyond yielding) in pure tension and 2·5% in eccentric tension.

Etching and polishing studies on magnesium oxide single crystals. By T. K. Ghosh and F. J. P. Clarke, A.Inst.P.
The action of two etchants on magnesium oxide has been studied. Etch pits, pyramids and hillocks may be produced and both etchants dissolve away the crystal surface. Activation energies for dissolution are estimated and the etching processes discussed with particular reference to dislocations and impurities.

Barium-carbon monoxide system: an hypothesis of Arizumi and Kotani. By T. A. G. Giorgi, Grad.Inst.P., and S. Origlio.
According to Arizumi and Kotani carbon dioxide may be formed from carbon monoxide owing to the catalytic action of a barium getter deposit. This hypothesis has been experimentally investigated using a ion resonance mass spectrometer of the omegatron type. It has been shown, using the dynamic sorption measuring technique at constant pressure on the getter film, that there is no such catalytic action. The results obtained indicate that the experimental behaviour observed by Arizumi and Kotani, and which warranted their hypothesis, is due to outgassing of the sealed-off system.

Interferometric measurement of small angular displacements Part 2. The double-passed Jamin interferometer. By P. Hariharan, A.Inst.P., and D. Sen.
When the rays emerging from a Jamin interferometer are reflected back through the instrument, fringes similar in appearance and behaviour to three-beam fringes are obtained. These fringes can be used to measure small angular displacements of one of the beam-dividing plates, with an

accuracy of the order of 0·01°. A modified set-up is also described with which angular displacements of a comparatively light, auxiliary mirror can be measured with the same degree of accuracy.

Shaft position indicator for use with journal bearings. By J. J. Hunter and C. J. Hughes.
A description is given of equipment using transistors and designed for the indication and measurement of the position of the shaft within the bush of a journal bearing system. Shaft movements cause variations in the impedance of inductive transducers, unbalancing the a.c. bridge of which they are part. The bridge output, in the form of an amplitude-modulated carrier, is supplied to an a.c. amplifier and then demodulated to recover a voltage proportional to shaft displacement. By monitoring the bearing on two diameters at right angles and supplying the demodulator outputs to the *X*- and *Y*-plates of a cathode-ray oscilloscope, a polar plot of shaft movement is possible and the form of vibration can be observed directly. Although designed for use on a bearing of about 1 in. diameter, the equipment is easily adjustable for other bearing sizes and can give useful information with shaft speeds up to 20000 rev/min.
Circuit details are given and discussed and an assessment is made of the accuracies of the various units.

Method for calculating boundary value problems in heat conduction for the cylindrical cavity and the half space, by means of convolution integrals. By D. W. Jordan.
A convenient method for obtaining approximate solutions to certain types of boundary value problems in heat conduction is by the use of convolution integrals. The method can be used when no analytical solutions exist, or when they are too complicated to apply. An advantage is that attention can be confined to the temperature variation at one point, say, on the surface, whereas finite difference methods require the temperatures over the whole field to be computed. In this paper surface temperatures are principally considered, and a table of the function required for computations relating to a cylindrical cavity is presented.

Growth of crystals in glass. By J. G. Morley, A.Inst.P.
The devitrification characteristics of five Na_2O–SiO_2 glasses have been examined by a new method, and some empirical relationships, applicable over the range of compositions studied, have been established. Comparisons are made with results given in other published work.

Pulse method for measuring Kerr's constant. By A. Pickara and R. Konopka.
A pulse method is proposed for measuring Kerr's effect as produced by a pulse saw-form electric field of a duration of 5×10^{-4} sec. The method served for investigating the electro-optical birefringence of liquids whose conductivity was so high as to rule out the use of static methods of measurement.
Kerr's constant was measured in o-nitrobenzene, m-nitrotoluene and nitrobenzene, these liquids presenting a conductivity ranging from 10^{-7} to $4 \times 10^{-11}\ \Omega^{-1}\text{cm}^{-1}$.

Summarized proceedings of a conference on stress analysis—University College of North Staffordshire April, 1960. By C. D. Pomeroy.
The Annual Conference of the Stress Analysis Group of The Institute of Physics was held at the University College of North Staffordshire, Keele, Staffordshire, April 11th–13th, 1960. The papers, which were concerned primarily with polymers and fibres, are summarized in this article.

Interpretation of ultrasonic echo amplitude. By J. C. V. Rumsey.
The equation

$$S = S_0 \sqrt{\left\{ \int_0^{\frac{4aT/R}{x}} J_1(x) \right\}^2 dx}$$

is deduced for the amplitude S of the signal received by a transducer, radius a, from a circular discontinuity, radius T, which is plane and parallel to the transducer face at a distance R, where $k = 2\pi/\lambda$ and $x = kat/R$, S_0 being an arbitrary reference amplitude. Experiments verifying the equation are described, and the results quoted. The equation is shown to be more generally applicable than one recently put forward by Krautkrämer. It is shown that the equation obviates the use of the many test-blocks at present used in ultrasonic inspection.

Journal of Scientific Instruments

Small high-temperature vacuum furnace. By G. Arthur and J. H. Priest.
A small high-temperature vacuum furnace, using tantalum as the heating element, is described. The main features of the furnace are its simplicity of construction, the absence of internal water cooling and the comparatively low power requirements (2·5 kw at 2200°c).

A platinum resistance thermometer for use at high temperatures. By C. R. Barber, F.Inst.P., and W. W. Blanke.
The design and performance of a platinum resistance thermometer for high temperatures are described. The thermometer bulb is 36 mm × 5·5 mm and is contained in a recrystallized alumina sheath 500 mm long and 8 mm in external diameter. The coil is wound from very pure platinum wire ($\alpha = 0{\cdot}003926$) of diameter 0·3 mm and is freely exposed to dry air. The coil resistance at 0°c is 1·4Ω and this permits measurements to the equivalent of 0·002°c. The thermometer is found to be stable to this limit on heating it for one hour at 1063°c.

A simple 'constant-temperature' laboratory crystallizer. By B. M. Bartlett.
A description is given of a simple laboratory crystallizer employing a novel centrifugal system for the circulation of solution.

Automatic recording dilatometer. By C. L. Bell.
The dilatometer described here enables changes in volume with time to be followed automatically and with high precision. Thus chemical reaction rates can be obtained directly without the need for graphical differentiation.

An analogue method for computing the number of spins contributing to a magnetic resonance absorption. By V. R. Burgess.
An analogue method is described by which the number of spins contributing to a magnetic resonance absorption line may be computed from a recorder tracing of the derivative of the line. The area under an absorption profile is proportional to the first moment of the algebraic area under its derivative, it may be determined by a simple balance and cardboard cut-outs of the tracing.

Modified design for ion-source canals. By K. R. Chapman and G. L. Wrenn.
The possibility of replacing the orthodox cylindrical ion-source canal by a series of diaphragms is considered and some advantages of this modification are described.

Instrument for recording the dust nuisance emitted by chimneys. By P. A. E. Crouse, D. H. Lucas, F.Inst.P., and W. L. Snowsill.
A new type of instrument has been designed to measure and record the likelihood of dust emitted from a chimney causing nuisance at ground level. The instrument measures the difference between the optical obscuration produced by a clean glass surface and that produced by the same glass surface when dust collected from a flue duct has settled on it. The method of collection is based on the assumption that vertical surfaces are more important in pollution than horizontal surfaces, and that coarse particles are more likely to cause nuisance than fine particles. Care has been taken in the design to eliminate errors normally associated with optical instruments of this nature, for example those caused by a dirty optical system, ageing photocells and lamps, and mains voltage and temperature fluctuations.
The instrument has a novel recording method which enables it to operate over an unusually large range of signal levels. It will facilitate the control of dust emision from industrial chimneys.

Low-inductance capacitor banks and linear pinched discharges. By A. H. Gabriel, V. T. S. Howell, E. Thornton and R. J. Wilson.
Details are given of low inductance capacitors, and capacitor banks with energy storages in the range 1 to 10 kJ capable of giving maximum currents of 1·2 ma and rates of rise of 6×10^{12} asec^{-1}. The working voltage in the work described is 10 kv, but the techniques have been used at higher voltages, up to 40 kv. An outline of the measurement techniques, used in the study of linear pinched discharges in low-pressure deuterium with these banks, is given.

New design of spectropolarimeter. By E. J. Gillham and R. J. King
A new design of spectropolarimeter is described in which the functions of monochromator and polarimeter are combined by using two crystalline quartz prisms both to disperse the radiation and to polarize it. The two prisms are fixed in position, wavelength scanning being achieved by the rotation of two plane mirrors in unison about a common axis. The optical rotation of the specimen is compensated by means of a Faraday cell and is thus measured in terms of current. The present experimental system can be used over a wavelength range from 600 to 220 mμ, the full-scale reading varying with wavelength, being equivalent to about 0·1° at 600 mμ and rising to about 1·1° at 220 mμ. The output noise level is between about 0·1 and 0·5% of the full-scale rotation over this spectral range.

SPECIAL ARTICLE

Some aspects of research on thin solid films. By K. M. Greenland, F.Inst.P.
The practical importance of the structure of thin films deposited *in vacuo* and of the relationship between film and substrate is illustrated by description of a number of new thin-film devices. A brief history of research on thin films leads to a survey of some recent work on the nucleation, growth and structure of films, examined by electron and field emission microscopy, and on the measurement of film-substrate binding energy.

Servo-operated respiratory waveform simulator. By D. W. Hill, A.Inst.P., J. R. Hook and E. G. Bell.
An apparatus for the generation of typical respiratory patterns is described. Two pistons are driven by a half horse-power servomotor operated by a Velodyne speed control system. The desired waveform is produced by means of a cam or photoelectric function generator.

Recording integrator for gas chromatography. By A. P. H. Jennings, A.Inst.P.
An automatic integrator is described based on the Velodyne principle, whereby a motor is caused to run at a speed proportional to the signal to be integrated. The total number of revolutions of the motor in a given period is proportional to the time integral during this period. The integral is recorded continuously in analogue form on the same chart as the input signal.
The basic units are standard commercial items and relatively simple additional circuitry gives a flexible control system. The accuracy obtainable is of the order of 0·5%.

Transistorized vacuum trip unit. By D. Jones.
A vacuum trip unit has been designed, using a thermocouple gauge and a transistorized d.c. amplifier, to operate relays in the interlock and protection circuits of a high-vacuum pumping system. The unit is simple to construct and set up, yet has proved stable and reliable in operation.

Mass spectrometer for the isotopic analysis of lithium. By R. G. Ridley and D. E. P. Silver.
A mass spectrometer has been designed for the routine analysis of lithium. Microgram samples of lithium nitrate are ionized in a thermal ionization source. A 60° sector magnet analyses the two ion beams which are collected simultaneously on two separate collectors.
The source is pulsed and the two signals are a.c. amplified and then subtracted from one another. The difference is displayed on a cathode-ray tube and the ratio is given rapidly by reading attenuation dials after adjusting for a null deflection. A calibration technique corrects for unequal transmission through the spectrometer and for inequalities in the circuitry. The precision of a single measurement of isotope ratio is ±0·7%.

Automatic apparatus for measurement of the rate of absorption or evolution of gas. By J. Scanlan and J. R. Dunn.
An apparatus is described in which constant pressure is maintained as gas is absorbed or evolved by changing that volume of a threaded rod which is inside the apparatus. The change in volume of the gas is then equal to the change in volume of the rod inside the apparatus. Use of an escapement to turn the screw through constant-volume increments provides a simple method of automation.

Technique for measuring the elastic properties of bitumens, tars and soils under dynamic loading. By E. N. Thrower.
A technique is described for the measurement of the components of the complex (dynamic) Young's modulus (E^*) and the complex rigidity modulus (G^*) of bitumens, tars and soils under sinusoidal loading. The equipment is capable of measuring the complex Young's modulus up to about $|E^*| = 5 \times 10^{10}$ dyn cm^{-2} (10^6 lb/in^2) and the complex rigidity modulus up to

$$|G^*| = 2 \times 10^{10} \text{ dyn cm}^{-2} \ (3 \times 10^5 \text{ lb/in}^2)$$

over the frequency range 5 to 500 c/s and at temperatures between —20 and +30°C.
To measure the complex Young's modulus, an axial sinusoidally varying force is applied to a cylindrical specimen by a moving-coil vibrator. Piezoelectric gauges are used to convert the force applied to the specimen, and the displacement of its driven end, into voltages, which are measured on a phase-sensitive voltmeter. The complex modulus is derived from a comparison of these voltages with those obtained using a steel calibration spring. For the measurement of the complex rigidity modulus, the material is sheared in the annulus between two cylinders, the inner being driven by the vibrator. The same two gauges now serve to measure the force applied to the inner cylinder, its displacement and their relative phase.

Automatic correction of counting loss ses in a Geiger-Mullercounter used with periodically varying radiation. By B. B. Trott.
Correction is achieved by reducing the number of uniformly-spaced timing pulses recorded during the reception of a particular number of pulses from the counter. The action and performance of a circuit which restricts to a suitable portion of the radiation cycle the registration of timing pulses is described.

Use of 'air bleed' when measuring pressure in vacuum processes in which condensable vapours are present. By H. Wycliffe.
Condensation may occur in a vacuum gauge which is used for measuring the presure in a vacuum system in which a liquid is being evaporated at elevated temperature and the pressure of the liberated vapour exceeds the saturation presure of this vapour at the temperature of the vacuum gauge, which is usually at ambient temperature. In this paper, a pressure-measuring method is described which prevents condensation or liquefaction occurring in the manometer or in the line connecting it to a vacuum system. The essence of this method is the reduction of the vapour pressure in the vacuum gauge, or in the pipeline leading to it, by a small stream of air, to a value at which condensation or liquefaction cannot occur. A short note is also added on the use of mercury manometers on 'wet' vacuum systems.

A flat field microscope objective. By C. G. Wynne, F.Inst.P.
The heavy field curvature found in the usual type of microscope objective of numerical aperture 0·65 is shown to be amenable to correction without complication of the basic five-glass form of construction. The relevant aberration theory is discussed, and numerical data are given for an N.A. 0·65 objective of ×40 magnification with substantially flat image field.

Proceedings of The Physical Society

Oscillations of a Plasma in a Static Magnetic Field. By N. Anderson.
We consider the propagation of waves through an infinite homogeneous plasma permeated by a static magnetic field. The Boltzmann equation is linearized by the usual perturbation method and the distribution function obtained in the form of an integral. From the expression for the distribution function we calculate the current density, which on insertion into Maxwell's equations gives the dielectric tensor relating the components of the displacement to those of the electric field. Explicit expressions are given for the components of the dielectric tensor in the particular case when the mean Larmor radius of the particles is considerably less than the wavelength of the oscillation and the wave velocity considerably greater than the mean thermal velocity of the particles. Under these conditions the change in the wave velocity due to thermal effects is calculated by means of an eigenvalue method which uses the wave velocity in the absence of thermal effects and the dielectric tensor we have calculated previously.

Ferromagnetic resonance in nickel–copper alloys. By D. M. S. Bagguley and M. Heath.
Ferromagnetic resonance absorption has been measured in a series of nickel-copper alloys having compositions Ni 50% Cu 50%, Ni 45% Cu 55%, Ni 42% Cu 58% by weight. The temperature range over which measurements were made included the individual Curie points of the alloys. The experiments were carried out at 3·19 cm and 8·8 mm wavelength. Absorption lines were observed in both the ferromagnetic and paramagnetic phases, and the line width was found to be a maximum at the Curie point. It was also frequency dependent, being roughly twice as great at 8·8 mm as compared with 3·19 cm. The 'g' factor had the value 2·22 ± 0·02 for the ferromagnetic phase of each alloy.

The law of Wiedemann and Franz. By G. V. Chester and A. Thellung.
The exact expressions for the transport coefficients of a metal are used to show that the Wiedemann–Franz Law is valid provided that (*a*) the electrons do not interact with each other and form a degenerate Fermi–Dirac assembly, (*b*) the scattering of the electrons is due to impurities or lattice vibrations and is elastic. The derivation is valid no matter how strong the scattering and it is therefore more general than the usual weak-coupling derivation of the Wiedemann–Franz Law.

The effect of electrodes in a linear pinched discharge. By M. G. Haines.
A linear pinched discharge in fully ionized hydrogen or deuterium is examined theoretically under an idealized steady state condition, when there is a pressure and an energy balance and no instabilities. Under this condition, the joule heating caused by the axial current is balanced by bremsstrahlung radiation losses and by axial heat conduction and diffusion to the electrodes. A partial analytical solution is found assuming that the transport coefficients have the usual power dependences on temperature throughout the plasma. It is shown that all the energy not radiated is carried to the anode, the cathode even having a negative total heat flux at its surface due to thermal diffusion by the current-carrying-electrons. The maximum temperature in the discharge is shown to vary directly with the voltage across the tube and only insensitively to other parameters. Further relations are derived involving the dimensions of the discharge, the current and the maximum temperature. The temperature, the line density, and the electric field are plotted showing their variation along the axis. The relative importance of heat conduction and radiation losses is seen to depend only on the total axial current which is flowing. A typical example of a discharge shows that temperatures of 10^8 deg K to 10^9 deg K are quite feasible in the presence of heat losses to the electrodes.

The 2^3S excitation in helium. By G. S. Higginson and L. W. Kerr.
A simple diffusion method has been employed to measure the shape of the excitation probability curve above the threshold of the 2^3S excitation in helium. The results are in substantial agreement with those of Schulz and Fox.

Polarization of 9 MeV Protons elastically scattered from C and Al. By D. Hoare, A. B. Robbins, and G. W. Greenlees.
Angular distributions are presented for the differential cross section and polarization of 9 mev protons, elastically scattered from C and Al, in the angular range 20°–140° (c. m.). The results are compared with the predictions of an optical model analysis.

A note on non-equilibrium elastic constants. By M. A. Jaswon and B. J. Shaw.
A new tensor invariant is introduced into elasticity, viz. the work done by a system of fixed initial stresses in generating second-order dilatations. The effect of the latter can therefore be systematically accounted for, in a crystal of any symmetry class, when making lattice theory calculations of non-equilibrium elastic constants. Two examples of such calculations are included.

A study of the reaction ^{44}Ca(d, n)^{45}Sc. By B. E. F. Macefield, J. H. Towle and W. B. Gilboy.
The neutron time of flight technique has been used to study the reaction ^{44}Ca(*d*, *n*)^{45}Sc. A ground state *Q* value of — 1·145 ± 0·015 mev was obtained which disagrees with previous measurements. Excited states of ^{45}Sc have been located at 1·709 ± 0·030 mev and 2·476 ± 0·030 mev. Angular distributions of the corresponding neutron groups have been measured. The application of Butler stripping theory enables an assignment of $l=3$ for the captured proton for the ground state and $l=1$ for the 1·71 mev state. An unambiguous assignment is not possible for the 2·48 mev state.

The anisotropy of Young's modulus in drawn polyethylene. By G. Raumann and D. W. Saunders.
The macroscopic physical properties of a partially crystalline polymer become anisotropic when the polymer is drawn i.e. when the polymer undergoes a large permanent deformation from its isotropic state. The anisotropy of refractive index, x-ray scattering etc. has been investigated by many workers. In this paper the anisotropy of Young's modulus in samples of polyethylene, drawn by simple tensile loading so as to have transverse isotropy, is studied experimentally at room temperature, 20°C. According to classical elasticity theory the Young's modulus of a transversely isotropic material can be defined completely in terms of three independent parameters. These have been chosen to be E_a, E_{45} and E_{90}, the Young's moduli at angles 0°, 45° and 90° to the symmetry axis respectively. It is found that (*a*) the polar distribution of Young's modulus in highly drawn polythylene (draw ratio 4·65) agrees well with the distribution predicted by classical elasticity theory. (*b*) at draw ratios up to about 1·2, E_a, E_{45} and E_{90} all decrease from the isotropic value and $E_{45} > E_{90} > E_a$. (*c*) at draw ratios greater than 1·2 E_a and E_{90} both increase with increasing draw ratio but E_{45} continues to decrease. (*d*) in the highly drawn material, draw ratio about 4·65,

$$E_a \simeq 1{\cdot}5\ E_{45} \simeq 12\ E_{45} \simeq 5E_{90} \text{ 'isotropic'}$$

These results are discussed in terms of the classical theory of elasticity.

The luminescent decay of various crystals for particles of different ionization density. By J. C. Robertson and J. G. Lynch.
New measurements of the decay of the luminescence produced in LiI(Eu), NaI(Tl), KI(Tl), CaBr(Tl) and three CaI crystals of varying thallium concentration have been made for particles with different ionization densities. The detailed shape of the decay is found to depend on the average ionization density ρ. In all cases except LiI(Eu) a short and a long component are found in the decay. The behaviour of efficiency and decay times with thallium concentration for different particles has been studied in CaI. The ratio has been found to increase with the average ζ of the crystal where τ', and τ'', are the average decay times for electrons and alpha particles respectively. A possible mechanism for the luminescence is discussed.

Nuclear and relativistic effects in atomic spectra. By A. P. Stone.
The electronic Hamiltonian for a general atom is obtained as far as terms in $1/c^2$ and m/M_A by reducing a relativistic wave equation with four components for each electron and nucleon to an approximately relativistic form with two components per particle. The presence of non-Hermitian terms in the reduced Hamiltonian is explained. Relativistic corrections to the Coulomb and nuclear interactions and the effect of the intrinsic magnetic moments are treated by first-order perturbation theory. The electronic Hamiltonian is obtained in the centre-of-mass system of the atom. The hfs interaction is obtained by expressing all electron–nucleon terms as multipole expansions, giving the previously known hfs expansion with recoil corrections. The exact operator for the nuclear field effect in isotope shift is obtained from the Coulomb interaction. The presence of other corrections depending on nuclear structure is indicated. Terms

referring only to s electrons are not considered as the reduction procedure used does not cover the contact approach of particles. The usual calculation of the normal mass effect in isotope shift is investigated for non-s electron configurations and shown to be justified if 0·1% of the spin-orbit interaction and the whole of the other relativistic perturbations are negligible in comparison with the term value.

Faraday effect for direct magneto-optical transitions in germanium By N. Suffczynski.

The Faraday effect due to the interband magneto-optical transitions in germanium is calculated. The direct transitions from the uppermost Landau levels of the two light hole ladders and two heavy hole ladders are considered. The magnitude of the effect depends sensitively on the effective masses of the levels in the presence of the magnetic field.

The heat capacities of some copper–manganese alloys. By J. M. Titman.

The anomalous behaviour of the heat capacities at the Néel points of copper–manganese alloys containing 80 and 85 at. % Mn is more marked than that observed in other metallic antiferromagnetics. The entropies associated with the anomalies are 0·20 and 0·25 cal mol^{-1} deg^{-1}, respectively, and are significantly less than the value $R \log (2S+1)$ predicted by localized theories of antiferromagnetism. It is concluded that these results indicate that the appropriate model of antiferromagnetism in metals is not one based on completely localized moments.

LETTERS TO THE EDITOR

Cubic crystal field splitting of the Gd^{+++} ion. By R. Lacroix.

The calculation of the Debye characteristic temperatures. By N. M. Wolcott.

A Nuclear Physics Conference

is to be held in

The University of Birmingham

April 17, 18 and 19, 1961

This Conference will be sponsored by The Institute of Physics and The Physical Society

It is proposed to devote sessions to the following:—

(i) γ-ray scattering

(ii) Low Energy Nuclear Reactions
Nuclear Models

(iii) Instrumentation and Machines

(iv) Nucleon-Nucleon and Nucleon-Nucleus High Energy Physics

Programmes and application forms will be available in mid-February from the Conference Secretary, Department of Physics, The University, Edgbaston, Birmingham, 15.

Symposium on Electrical Contacts

The Institute and Society in collaboration with The Institution of Electrical Engineers is arranging a symposium on "Electrical contacts" to be held at Brunel College of Technology, London, on April 5 7, 1961.

Topics will include:

Electrical erosion and material transfer

Mechanical wear

Influence of surface films and contamination

Make-and-break contacts.

Sliding contacts

Semi-permanent contacts and connexions between metallic and non-metallic materials.

Major interest will be focused on contact resistance.

The Symposium is intended mainly for persons concerned with the design and improvement of contacts.

There will be a small informal exhibition.

Programs and enrolment forms will be available at the end of January from The Secretary of the Institute and Society.

PHYSICIST

Aged 21-28 with good-class honours or higher degree is offered an opportunity to join a team which is making Design Studies and doing other exciting theoretical work on new semiconductor Devices such as Tunnel Diodes, Alloy Junction, Diffused and Power Transistors.

The Division, with its associates on the Continent and in the U.S.A. is in the forefront of Semi-conductor technology.

Its Laboratories are situated in Sidcup, Kent, only 11 miles from Central London and every encouragement will be given to attend professional society meetings.

Informal evening or Saturday morning interviews with the Division's Senior Scientists can be arranged and at these interviews we shall be glad to explain the Company's generous non-contributory Pension Scheme and Sickness Benefit Plan and how the Company can assist with housing.

Write, in confidence, giving a personal history of age, qualifications, experience and salary to:

W. J. Yeomans,
Personnel Manager,
Standard Telephones and Cables Limited,
Footscray, Sidcup, Kent.

(FOO. 3333, Ext. 223)

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE

(A constituent College of the University of Wales)

Department of Physics

Applications are invited for four posts in the Department of Physics:

A. One LECTURER at a salary on the scale £1,050 × £50–£1,400 × £75–£1,475 (bar) × £75–£1,850 per annum.

B. One ASSISTANT LECTURER at a salary on the scale £850 × £50–£950.

C. One RESEARCH ASSISTANT at £750 per annum, for crystal-structure determination and limited teaching duties. This appointment, which is renewable annually for not more than three years, provides good scope for work for the degree of Ph.D.

D. One RESEARCH ASSISTANT for work on identification by X-ray diffraction methods and limited teaching duties. Salary according to qualifications, but not less than £750 per annum. This post, which is renewable from year to year, may offer scope for research for the degree of M.Sc.

Candidates for posts A and B with exceptional qualifications may be appointed at a salary above the bottom of the scale. F.S.S.U. and family allowances for candidates satisfying the usual requirements. Duties to commence October 1, 1961.

Applications (*six copies for posts A and B, and two copies for posts C and D*), giving the names of three referees, should be sent to The Registrar, University College, Cardiff, from whom further particulars may be obtained. Closing date for applications January 31, 1961.

RESEARCH FELLOWSHIPS

THEORETICAL PHYSICS INSTITUTE

UNIVERSITY OF ALBERTA EDMONTON, CANADA

Applications are invited for post-doctoral research fellowships in theoretical physics. Fellowships carry a stipend of $6,000 p.a. with annual increments of $500 and are tenable for periods up to three years. Removal assistance is provided by the Institute.

Applicants should ask two or three referees to write letters of recommendation. In addition, applicants should state their age, qualifications and experience and supply a list of publications.

All correspondence should be addressed to

L. E. H. Trainor,
Physics Department,
University of Alberta,
Edmonton, Canada

from whom additional particulars may be obtained.

PHYSICIST

If you have a good honours degree in Physics and would like to hold a responsible job in an expanding industry, you are invited to write about yourself to

Dr. J. B. Higham,
Head of Technical Development,
Pilkington Brothers Ltd.,
St. Helens, Lancashire.

You would be required to set up a new model laboratory where air and water model techniques will be used to study flow patterns of glass in melting units and combustion conditions with reference to port and regenerator design.

AUSTRALIA
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

RESEARCH PHYSICIST

The Organization's Division of Metrology, National Standards Laboratory, Sydney, N.S.W., invites applications for the position of Research Physicist in the Interferometry Section from Honours graduates, majoring in Physics with some years postgraduate research experience, preferably to Ph.D. level.

The Section, which has a well-equipped vacuum coating laboratory as well as equipment for studying surfaces and thin films by multiple-bean interferometry, is engaged on research and development in interferometry, particularly the measurement of length and associated quantities such as flatness, surface structure and optical phase change at reflection. The appointee is required for research in interference spectroscopy and light source development involving the production study and use of various spectral radiations from isotopic light sources as primary and secondary wavelength standards in metrology.

SALARY: Dependent on qualifications and experience within the ranges:—£A1,510–£2,265 p.a. or £A2,395–£2,720 p.a.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made. Fares paid. Further information on conditions, etc., supplied on application to:—

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2

to whom applications (quoting Appointment No. 750/222) should be addressed by **February 11, 1961.**

COLD-CATHODE TUBE DEVELOPMENT

Applications are invited for the post of

Physicist/Engineer

in the

RESEARCH/DESIGN SECTION
of the Tube Division of Ericsson Telephones Ltd.

A knowledge of physics up to degree standard is required, and previous Industrial experience in vacuum techniques is desirable.

The post is a permanent staff appointment, and will carry a salary in accordance with qualifications and experience. There are good prospects in an active and expanding organization, with participation in the PensionScheme after qualifying period. Canteen facilities are available, and there is excellent provision for sports and social activities.

Applications, which will be treated in strict confidence, should be addressed to:

The Personnel Manager
ERICSSON TELEPHONES Ltd.
Beeston, Nottingham,
quoting reference LK/1.

IMPERIAL CHEMICAL INDUSTRIES LIMITED

CENTRAL INSTRUMENT SECTION

has a vacancy for a

PHYSICIST
or
ELECTRICAL ENGINEER

with a good honours degree for work in its Head Office Group in London.

Candidates not over 30 years of age should have, preferably, a knowledge of the basic principles of instrumentation and control engineering problems. Experience in this post of the Company's organization and its instrumentation practice will fit a man after some two years for a transfer to a suitable vacancy in one of the Company's manufacturing Divisions and for the right man the post is one which offers the possibility of rapid promotion.

Further details of this post can be obtained by telephoning Victoria 4444, Extension 340 (quoting C.E.1) or by sending a postcard to the Head Office Staff Department (C.E.1), Imperial Chemical House, Millbank, London, S.W.1.

The
OSRAM LAMP DIVISION
of
The General Electric Co. Ltd.
requires

A GRADUATE
in
PHYSICS

The Osram Lamp Division wishes to engage a graduate in Physics for their new and expanding Discharge Lamp Laboratory at Shaw, near Manchester.

A young and recently qualified Physicist is invited to join a team of engineers concerned with the development of new and improved light sources and the physics of their design and processing. Close collaboration with production teams and research colleagues is essential. This position can lead, apart from a technical career, to responsible posts on production or the administrative side with the Lamp Division.

Apply giving details of qualifications and experience (if any), to the

Senior Personnel Officer,
Osram Lamp Division,
G.E.C. Estate, East Lane,
North Wembley, Middlesex.

Insurances for Physicists

☐ **RETIREMENT PENSIONS** with full Tax Relief (1956 Finance Act)

☐ **ENDOWMENT ASSURANCE.** An adaptable policy providing protection for dependants, a good investment and a Tax-free capital sum on retirement.

☐ **NON-CANCELLABLE SICKNESS AND ACCIDENT INSURANCE,** providing an income during disablement up to age 65.

☐ **HOUSEHOLDERS COMPREHENSIVE INSURANCE** on Buildings and/or Contents with No Claims Bonus.

☐ **MOTOR INSURANCE.** Special Scheme with immediate 33⅓% No Claims Bonus
(PLEASE SEND DETAILS OF CAR FOR QUOTATION PURPOSES)

Name..... Date of Birth.....
(BLOCK LETTERS PLEASE)

Address .....

These policies are of particular interest to physicists.

For further details please complete this form and send to :

WALTER HERRIOT & CO. LTD.
Incorporated Insurance Brokers
Broad Street House, 54 Old Broad Street, London, E.C.2
(Telephone : LONdon Wall 7007/8)

UNITED KINGDOM ATOMIC ENERGY AUTHORITY
THE RADIOCHEMICAL CENTRE, AMERSHAM

CHEMISTS AND PHYSICISTS

The use of radioisotopes, labelled compounds and radiation appliances continues to grow rapidly in many branches of medicine, industry and research. Production and development of these important materials affords wide scope and interest for chemists and physicists, and the Centre invites applications from those suitably qualified in organic or inorganic chemistry, or in physics.

Selected candidates will be offered appointments in the Scientific or Experimental Class. A good honours degree is an essential qualification for entry into the Scientific Class, and a pass degree or an appropriate H.N.C., two "A" level passes in Science subjects, or other equivalent qualification for the Experimental Class.

Commencing salary related to age, experience and qualifications up to £1,365 in the Scientific Class and up to £1,110 in the Experimental Class with prospects of advancement to £2,460 and £1,900 respectively.

Superannuation and housing schemes.

Apply to the Personnel Officer, The Radiochemical Centre, Amersham, Bucks., quoting No. 22/1960/110.

From Dualism to Unity in Quantum Physics

A. LANDÉ

Professor Landé aims to give quantum physics a new and sound theoretical basis. He sets out to reduce the quantum phenomena to more elementary general principles, such as symmetry, invariance and continuity, and he develops the current Bohr-Heisenberg account into a unitary theory. A significant contribution to both physics and the philosophy of science. *18s. 6d. net*

The Major Achievements of Science

A. E. E. McKENZIE

The first book gives an account of the historical development of the main generalizations of science, their philosophical implications and their influence on the climate of western thought, with brief biographical accounts of outstanding scientists. The second book contains ninety-one extracts from the literature of science chosen to illustrate themes developed in the first volume. They have been chosen for their liveliness and human interest as well as for their scientific value

Library Edition, Book I, 30s. net; Book II, 17s. 6d. net
School Edition, Book I, 20s. net; Book II, 12s. 6d. net

Classical Electricity and Magnetism

E. S. SHIRE

A textbook for physics and engineering students, taking the subject to degree standard. The book is equally applicable to M.K.S. and C.G.S. systems. *45s. net*

CAMBRIDGE UNIVERSITY PRESS

AUSTRALIA
THE UNIVERSITY OF NEW SOUTH WALES
NEWCASTLE UNIVERSITY COLLEGE

SENIOR LECTURER IN PHYSICS

Applications are invited for appointment to the position of Senior Lecturer in Physics at the Newcastle University College. Salary: £A2,579 range £A3,029 p.a. Commencing salary according to qualifications and experience. Applicants should possess a higher degree or equivalent qualifications. The successful applicant will have special responsibilities for lecturing to and supervising the work of senior undergraduates and honours students. No restriction is placed on the field of specialization. The present staff of the Department is engaged in research in the fields of spectroscopy, electron optics, the solid state and solar energy. Special facilities exist for research work in the field of spectroscopy. There is an active research group in physical metallurgy in the Department of Metallurgy at the College. The University's digital computer, UTECOM, which is located in Sydney is also available for research purposes. The Department of Physics which forms part of the Division of Science of the College is associated with the School of Physics of the University of New South Wales in Sydney, headed by Professor C. J. Milner. The Department which at present has an academic staff of one senior lecturer and four lecturers at Newcastle is responsible for all pass degree courses in physics at the College, and in conjunction with the School of Physics of the University of New South Wales provides an honours course. In 1960 there were 325 students including those in engineering and applied science who were undertaking courses in physics of limited duration. Subject to passing a medical examination, the successful applicant will be eligible to contribute to the State Superannuation Fund. First Class ship fare to Sydney of the appointee and his family will be paid. Four copies of applications including the names of two referees should be lodged with the Agent General for New South Wales (Dept. HH), 56-57 Strand, London, W.C.2, England, and a copy forwarded to the Appointments Section, The University of New South Wales, Box 1, Post Office, Kensington, New South Wales, by airmail to reach there before February 3, 1961.

CHEMISTS, MATHEMATICIANS (including STATISTICIANS), PHYSICISTS, MECHANICAL and ELECTRICAL ENGINEERS (men and women) required for RESEARCH AND DEVELOPMENT ESTABLISHMENTS OF WAR OFFICE at various locations including Feltham, Middlesex; Sevenoaks, Kent; Byfleet, Chertsey and Tolworth, Surrey; Shoeburyness, Essex; Christchurch and Farnborough, Hants.; Salisbury, Wilts.; Cornwall (Chem. only), Anglesey (Maths.). Appointments in grades of (*a*) SENIOR SCIENTIFIC OFFICER (£1,250–£1,540) or (*b*) SCIENTIFIC OFFICER (£690–£1,144). Starting salary according to experience. Superannuation under F.S.S.U., with opportunity for candidates under 31 to compete for establishment (pensionable) posts. First or second class honours degree or equivalent required, and for (*a*) minimum age 27 and at least three years postgraduate research experience. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1. Quote: 'A.557/OA.

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

Applications are invited for (A) ASSISTANT LECTURESHIP or (B) LECTURESHIP IN PHYSICS. Salary scales: (A) £1,200 × £50–£1,350 p.a. (B) Grade II £1,350 × £50–£1,600 p.a. Grade I £1,600 × £50–£1,900 p.a. Passages to Salisbury for appointee, wife and dependent children on appointment, with allowance for transport of effects. Superannuation and Medical Aid Schemes. Unfurnished accommodation at rent of 15% of salary. Assistance given for triennial visits overseas. Detailed applications (six copies) naming three referees by January 30, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

FEDERAL GOVERNMENT OF NIGERIA

SCIENTIFIC OFFICER

(GEOPHYSICIST)

The Geological Survey Division of the Federal Ministry of Mines and Power have vacancies for Scientific Officers (Geophysicist) to conduct geophysical surveys using a.c. and d.c. resistivity apparatus, d.c. potential equipment, vertical forces magnetic variometer, shallow seismic gear, and equipment for logging resistivities and temperature gradients in boreholes. Candidates must hold a good honours degree in Geophysics, Physics, or Engineering. Alternatively a good honours degree in Geology, with Physics or applied Mathematics as subsidiary subjects. Experience in applied Geophysics, and some knowledge of Electrical Circuitry and an ability to maintain apparatus will be added advantages. Candidates should preferably not be over 35 years of age.

Contract: appointment for one tour of 15-18 months in the first instance with prospect of extension. Salary according to qualifications and experience £1,434–£2,196 per annum (including inducement addition) plus gratuity of £100–£150 on satisfactory completion of service. Outfit allowance of £60 payable for salaries not exceeding £1,740. Free passages for officer and wife. Liberal home leave on full pay. Quarters and income tax at low local rates. Children's allowances while separated.

Write for application forms and further particulars, stating briefly age, qualifications and experience, to

The Appointments Secretary, Federal Public Service Commission, Nigeria House,
9 Northumberland Avenue, London, W.C.2,
quoting J.3/10.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, LONDON

READER IN APPLIED NUCLEAR PHYSICS

The Governing Body invite applications for the above appointment in the Department of Applied Physics. Applicants should possess high academic qualifications and considerable research experience in this branch of Applied Physics. Salary scale: £1,836 rising to £2,148 p.a. Further particulars and a form of application can be obtained from: The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

THE UNIVERSITY OF LEEDS DEPARTMENT OF PHYSICS

Applications are invited for appointment in the Department of Physics as LECTURER or ASSISTANT LECTURER from October 1, 1961, or a date to be arranged at a salary on the scale £1,050 × £50 £1,400 × £75 £1,850 (efficiency bar at £1,550) a year for a Lecturer, or within the range £800–£950 a year for an Assistant Lecturer, according to age, qualifications and experience. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach The Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than February 20, 1961.

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY RESEARCH IN RHEOLOGY

Applications are invited from physicists for a position as experimental RESEARCH ASSISTANT in the DEPARTMENT OF MATHEMATICS to continue and develop a fundamental investigation of the rheological properties of concentrated polymer solutions. Recently developed apparatus is available for the measurement of flow birefringence and normal and shear stress components in shear flow. The work calls for initiative in the design and construction of new apparatus, and for the ability to perform series of observations of sustained accuracy. Candidates should possess a good Honours Degree in Physics. The position is tenable for two years in the first instance. Salary will be £675 per annum, and the post will be superannuable under F.S.S.U. Applications should be forwarded to the Registrar, The Manchester College of Science and Technology, Sackville Street, Manchester 1, on or before January 31, 1961.

PHYSICIST with electronic, and/or instrument experience, and preferably at least Honours Degree, required for fundamental and applied research in a growing organization concerned with building materials. Write for form of application to The Controller of Research, The British Plaster Board (Holdings) Ltd., East Leake, Nr. Loughborough, Leicestershire.

UNIVERSITY OF SYDNEY TWO LECTURESHIPS IN PHYSICS

Applications are invited for the above-mentioned positions. The successful applicants will be required to teach at First Year level, to supervise students' practical work, and generally to assist in the routine duties associated with the management of First Year classes. Opportunities for research will be provided. The salary for a Lecturer is within the range £A1,730 × £105 £2,435 per annum, plus cost of living adjustments and will be subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house. Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London, on January 31, 1961.

UNIVERSITY OF SYDNEY SENIOR LECTURESHIP AND LECTURESHIP SENIOR LECTURESHIP IN PHYSICS

Applications are invited for the above-mentioned posts. One appointee will work with Professor C. N. Watson-Munro in the field of plasma physics in the Wills Thermonuclear Physics Department and the other appointee will work with Dr. B. Y. Mills in the Chatterton Astronomy Department. The salary for a Senior Lecturer is within the range £A2,550 × £95 £3,000 per annum; for a Lecturer within the range £A1,730 £105 £2,435 per annum. In each case cost of living adjustments will be allowed. The salary is subject to deductions under the State Superannuation Act. The commencing salary and grade of appointment will be fixed according to the qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house. Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 3, 1961.

COURSES

UNIVERSITY OF LONDON

UNIVERSITY EXTENSION RESIDENTIAL WEEK-END COURSE

FUNDAMENTAL PARTICLES

AT MOOR PARK COLLEGE, FARNHAM, SURREY

FRIDAY EVENING FEBRUARY 24–SUNDAY AFTERNOON FEBRUARY 26, 1961

LECTURERS: PROFESSOR E. H. S. BURHOP, PROFESSOR J. HAMILTON

Inclusive fee £2 12s. Particulars and applications forms from Deputy Director (Ext.) Department of Extra-Mural Studies, Senate House, W.C.1.

BRADFORD INSTITUTE OF TECHNOLOGY

A seven weeks' full-time course in "NUCLEAR REACTOR TECHNOLOGY" will commence on February 13, 1961. Fee £30. Full particulars from the Registrar, Bradford Institute of Technology, Bradford 7.

ROYAL TECHNICAL COLLEGE, SALFORD

DEPARTMENT OF ELECTRICAL ENGINEERING

Head of Department:

J. H. CALDERWOOD, M.Eng., Ph.D., M.I.E.E., F.Inst.P.

A COURSE OF SIX LECTURES ON

ELECTRICAL INSULATION

will be given on Tuesdays at 7 p.m. commencing on February 7, 1961. The fee for the course is £1 11s. 6d. Further details may be obtained from the Head of the Electrical Engineering Department.

LANCHESTER COLLEGE OF TECHNOLOGY, COVENTRY

DEPARTMENT OF APPLIED PHYSICS

SHORT COURSE ON

RECENT ADVANCES IN NON-DESTRUCTIVE TESTING

FEBRUARY 23 - 24, 1961

A short course for physicists and engineers will be held on Thursday and Friday, February 23 and 24, 1961, and will include the following topics: Radiography, Internal Friction, Ultrasonics, Eddy Currents, Surface Crack Detectors, Electromagnetic Methods of Quality Control, Fluoroscopy and Economics. Fee: £1 2s. 0d. Full particulars and forms of application from the Head of the Department of Applied Physics, Lanchester College of Technology, Priory Street, Coventry.

PRINTED BY F. J. MILNER AND SONS LIMITED, BRENTFORD AND LONDON.